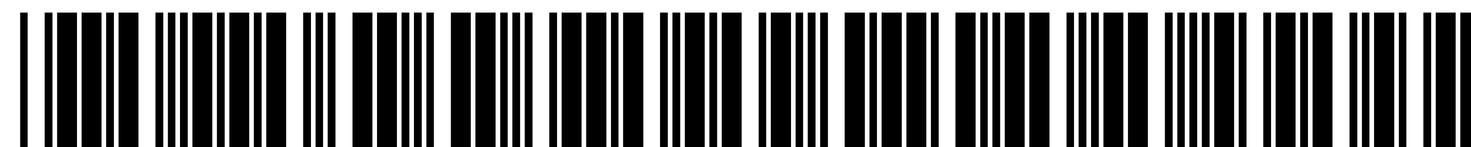


(12) **United States Patent**
Lebonheur et al.

(10) **Patent No.: US 7,294,533 B2**
(45) **Date of Patent: Nov. 13, 2007**

(54) **MOLD COMPOUND CAP IN A FLIP CHIP MULTI-MATRIX ARRAY PACKAGE AND PROCESS OF MAKING SAME**

(75) Inventors: **Vassou Lebonheur**, Tempe, AZ (US); **Richard J. Harries**, Chandler, AZ (US)

(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 433 days.

(21) Appl. No.: **10/612,764**

(22) Filed: **Jun. 30, 2003**

(65) **Prior Publication Data**

US 2004/0262776 A1 Dec. 30, 2004

(51) **Int. Cl.**
H01L 21/56 (2006.01)

(52) **U.S. Cl.** **438/127**; 29/856; 257/787; 257/E21.503; 257/E21.504

(58) **Field of Classification Search** 257/685, 257/688, 723, 737, 738, 778, 779, 782, 783, 257/789, 795, 787, E21.503, E21.504; 438/614, 438/108, 127; 29/856
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,128,746 A * 7/1992 Pennisi et al. 257/738
5,136,365 A * 8/1992 Pennisi et al. 257/783
5,218,234 A 6/1993 Thompson et al.
5,789,820 A 8/1998 Yamashita
5,817,545 A 10/1998 Wang et al.
5,874,783 A 2/1999 Yamada et al.
6,058,021 A * 5/2000 Yamamoto 361/783
6,434,017 B1 * 8/2002 Iwabuchi 361/771
6,438,826 B2 * 8/2002 Takase et al. 29/855
6,461,896 B1 * 10/2002 Imasu et al. 438/108
6,531,026 B1 * 3/2003 Takeichi et al. 156/282
6,727,583 B2 * 4/2004 Naka et al. 257/724
6,737,741 B2 * 5/2004 Imasu et al. 257/723
6,903,278 B2 * 6/2005 Sathe 174/255
6,919,642 B2 * 7/2005 Hsieh et al. 257/778
6,933,173 B2 * 8/2005 Yunus 438/110
6,940,182 B2 * 9/2005 Hilton et al. 257/787
6,995,476 B2 * 2/2006 Hashimoto 257/787
7,138,706 B2 * 11/2006 Arai et al. 257/678
2002/0060084 A1 5/2002 Hilton et al.
2002/0117762 A1 8/2002 Ikegami
2003/0082852 A1 5/2003 Fang

FOREIGN PATENT DOCUMENTS

EP 0740340 A2 10/1996
JP 2003-283295 * 3/2003 .... 9/25
WO WO-03050865 A1 6/2003
WO WO-2005006433 A2 1/2005
WO WO-2005006433 A3 1/2005

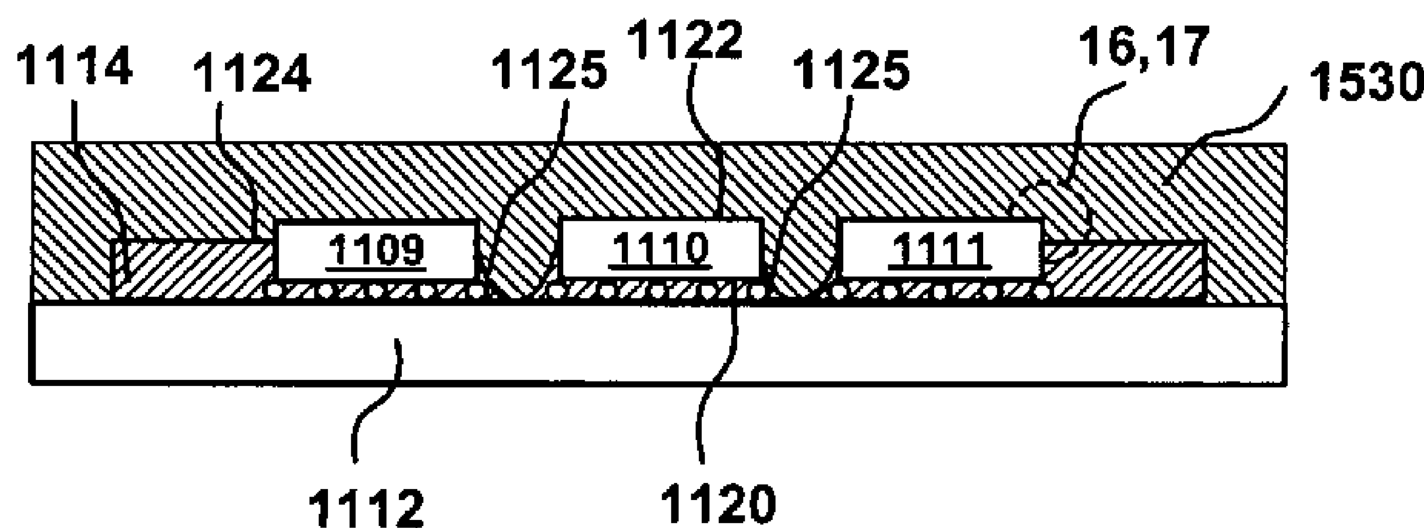
* cited by examiner

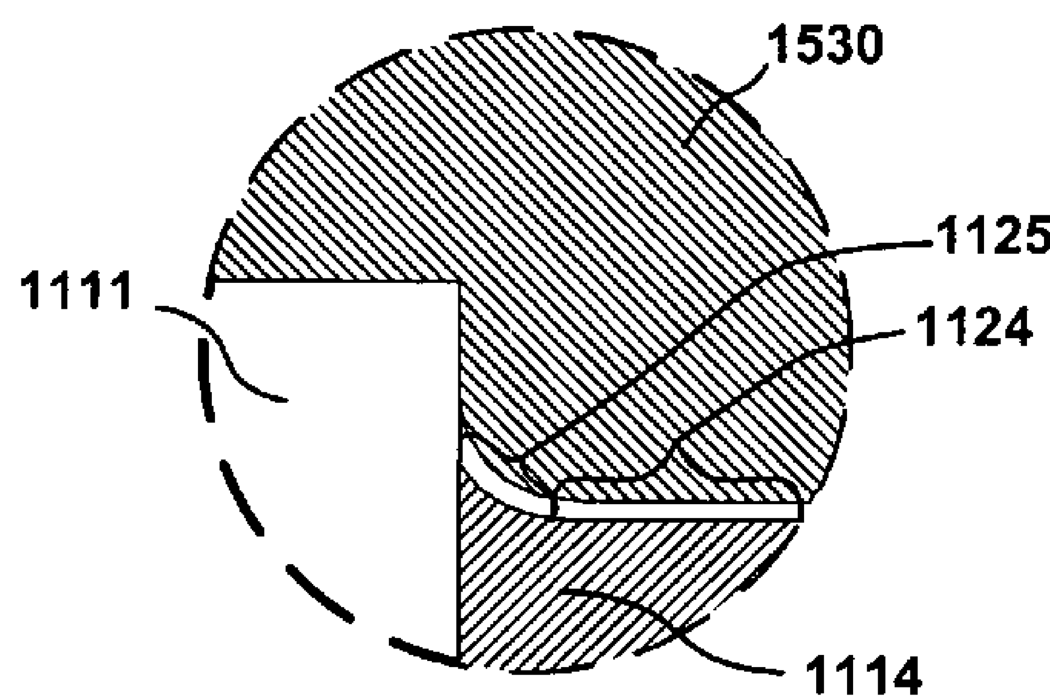
Primary Examiner—Evan Pert
Assistant Examiner—Victor A. Mandala, Jr.
(74) *Attorney, Agent, or Firm*—Blakely, Sokoloff, Taylor & Zafman LLP

(57) **ABSTRACT**

A molding compound cap structure is disclosed. A process of forming the molding compound cap structure is also disclosed. A microelectronic package is also disclosed that uses the molding compound cap structure. A method of assembling a microelectronic package is also disclosed. A computing system is also disclosed that includes the molding compound cap structure. The molding compound cap includes a configuration that exposes a portion of a microelectronic device.

10 Claims, 6 Drawing Sheets





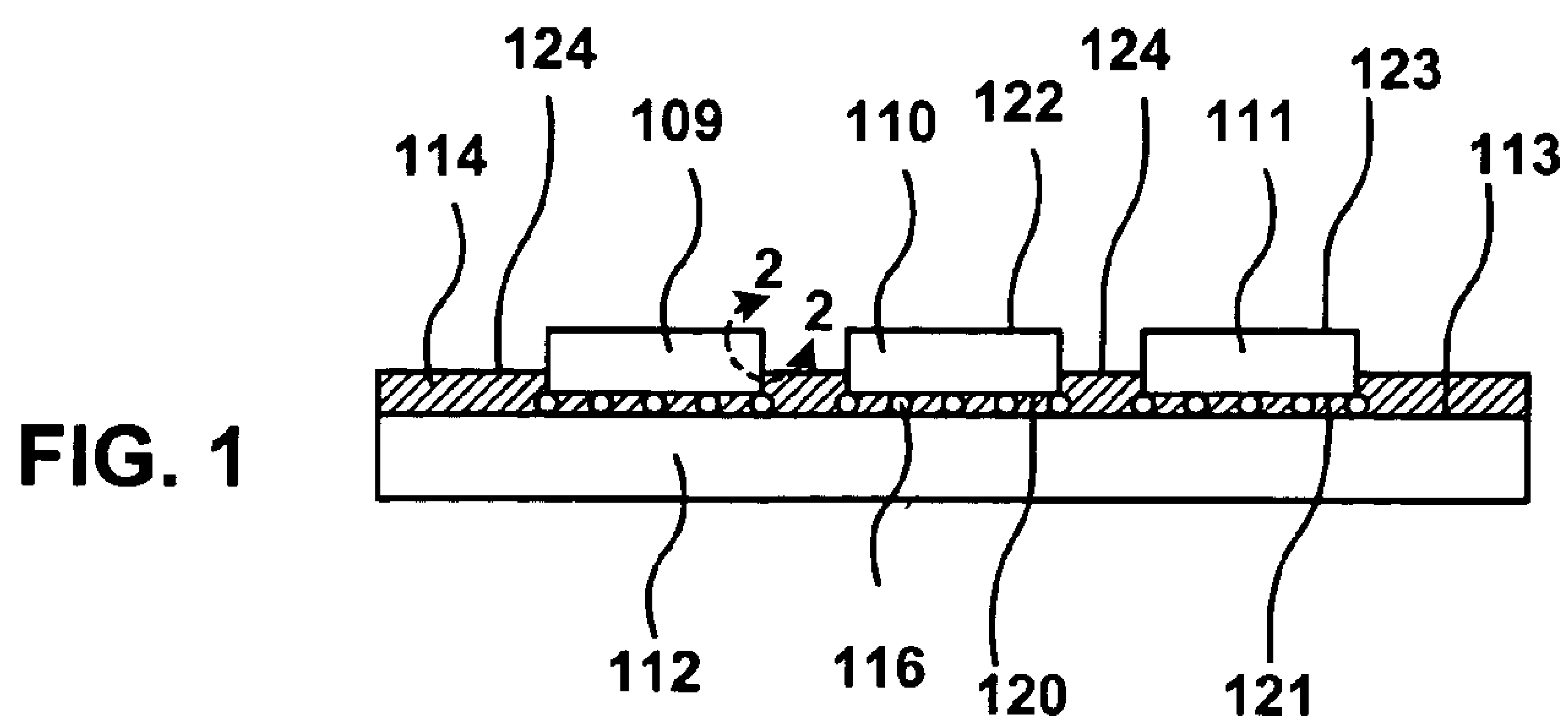


FIG. 1

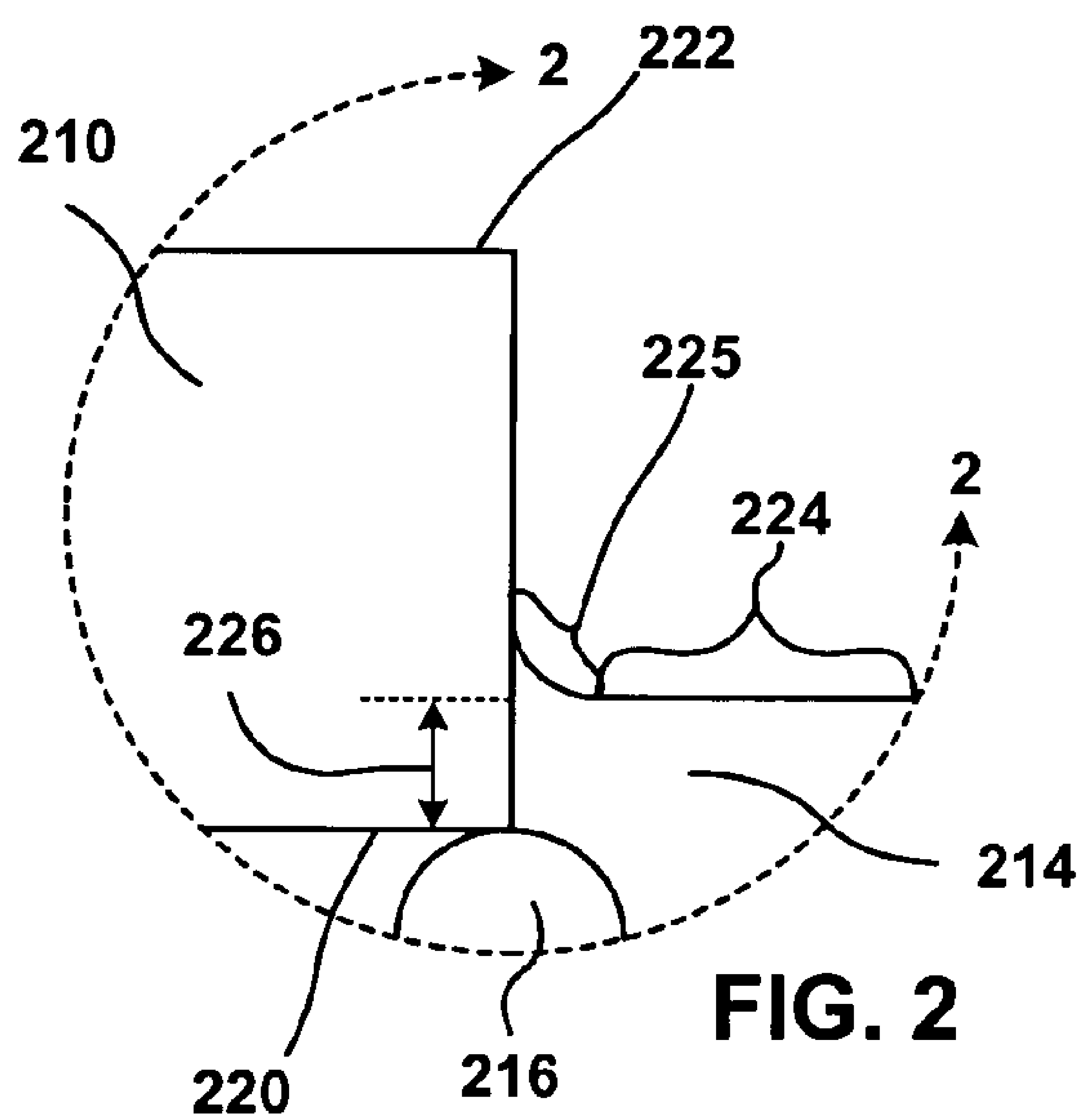


FIG. 2

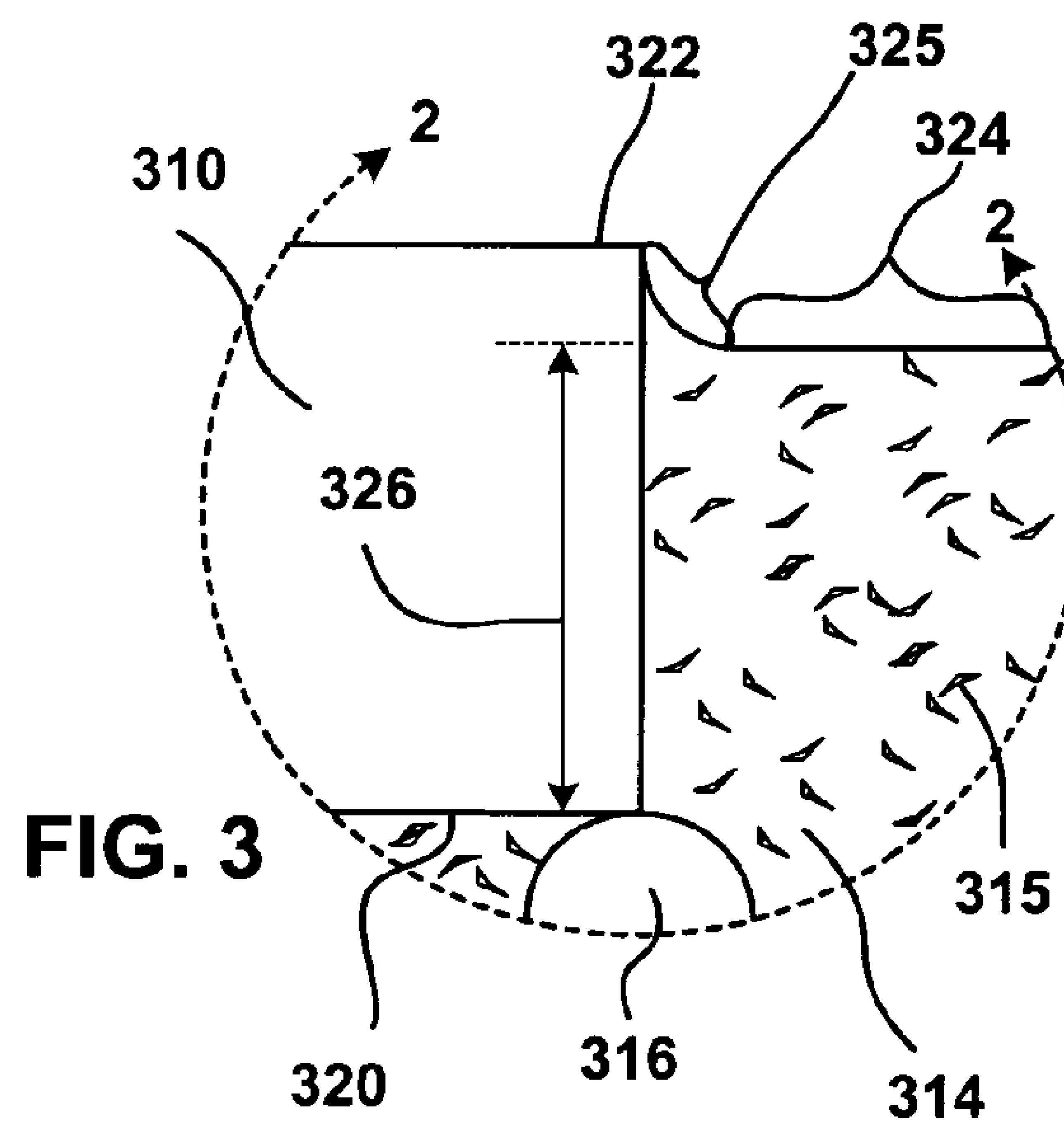


FIG. 3

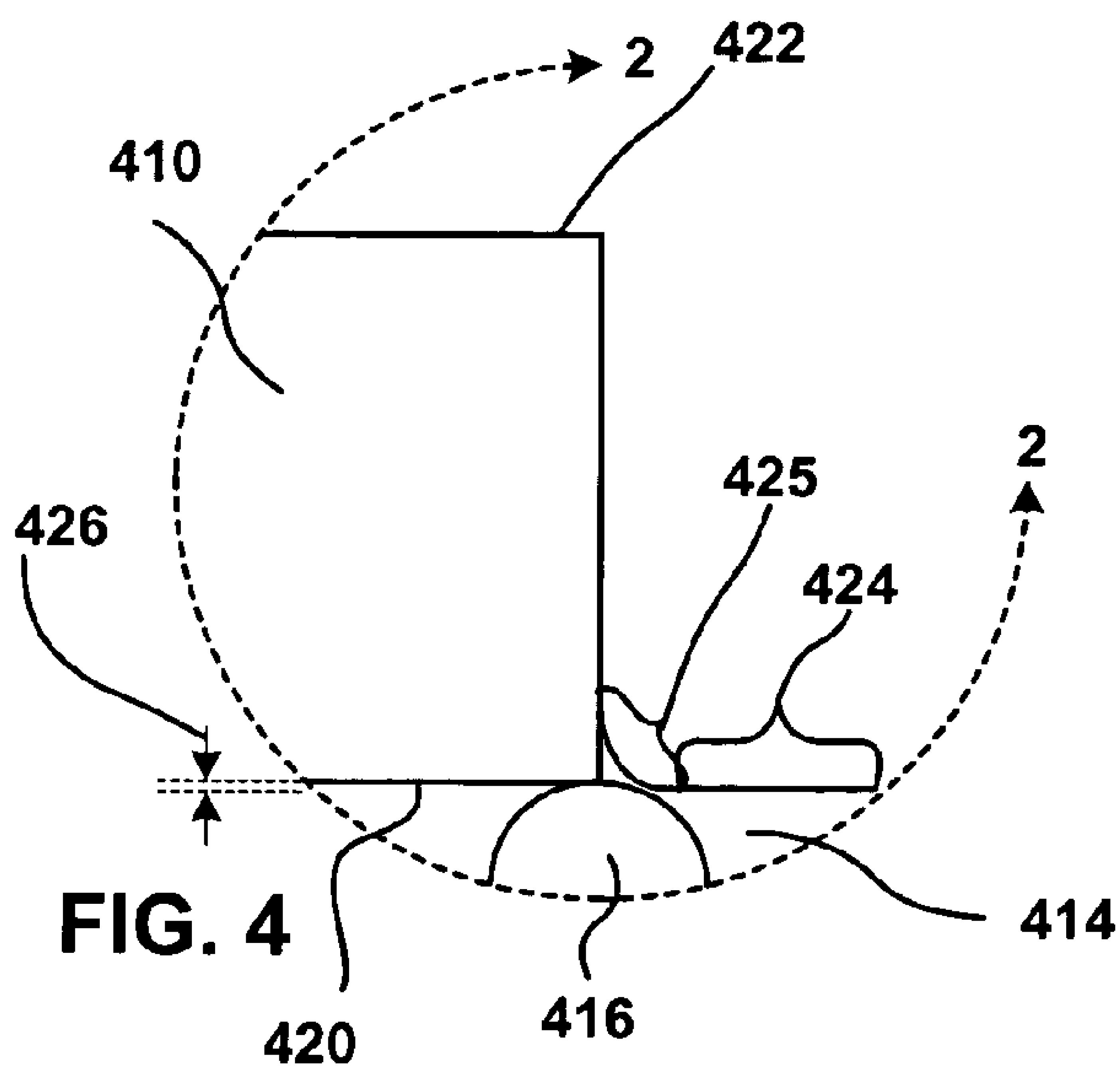


FIG. 4

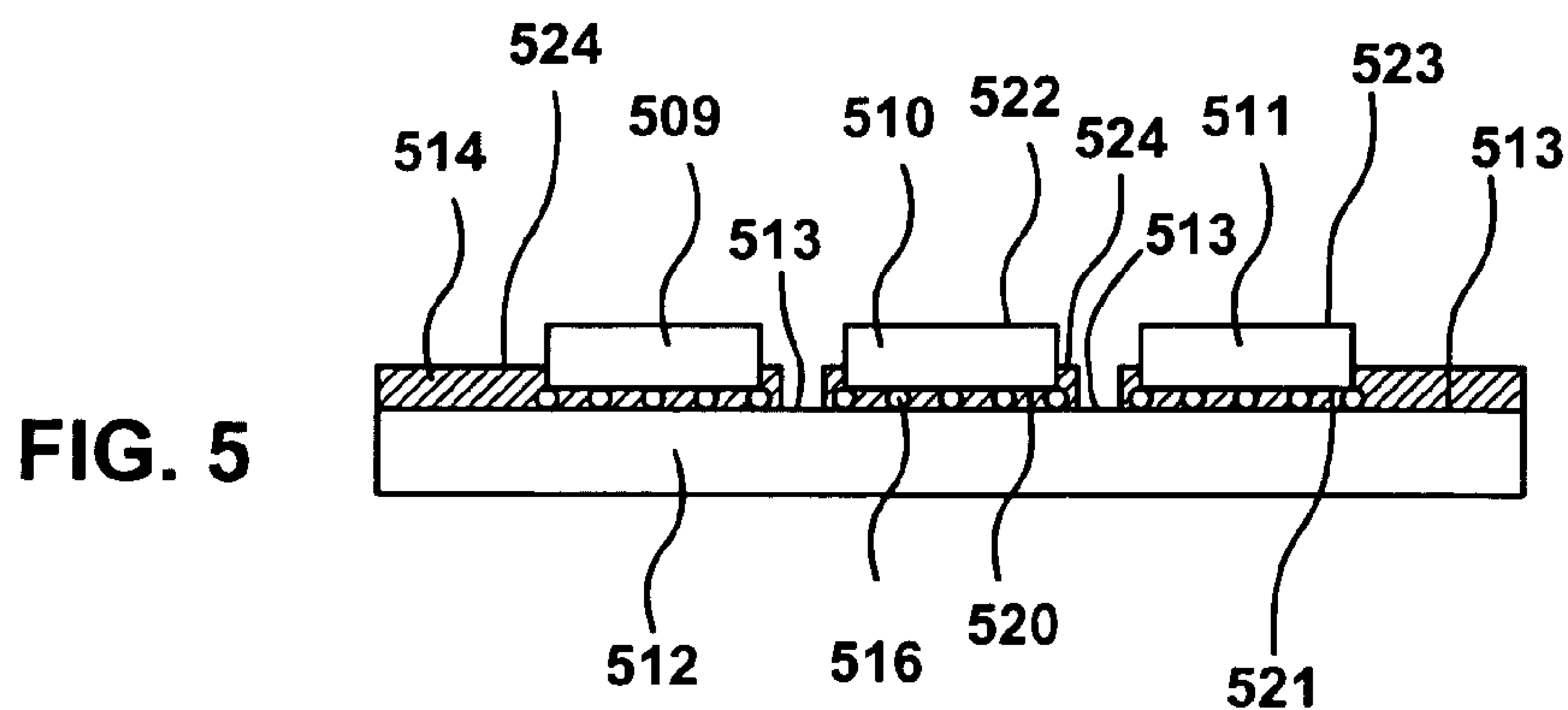


FIG. 5

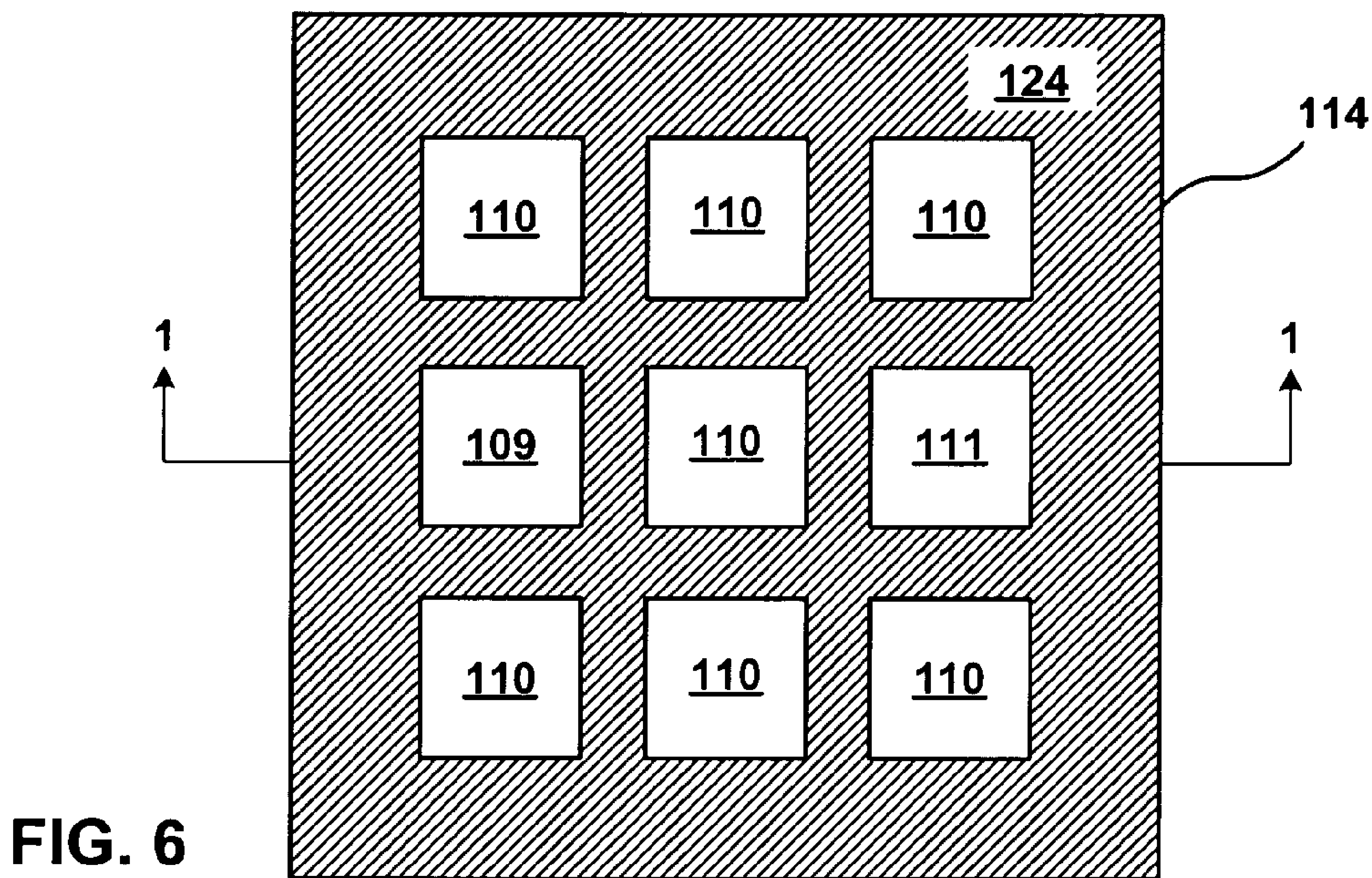


FIG. 6

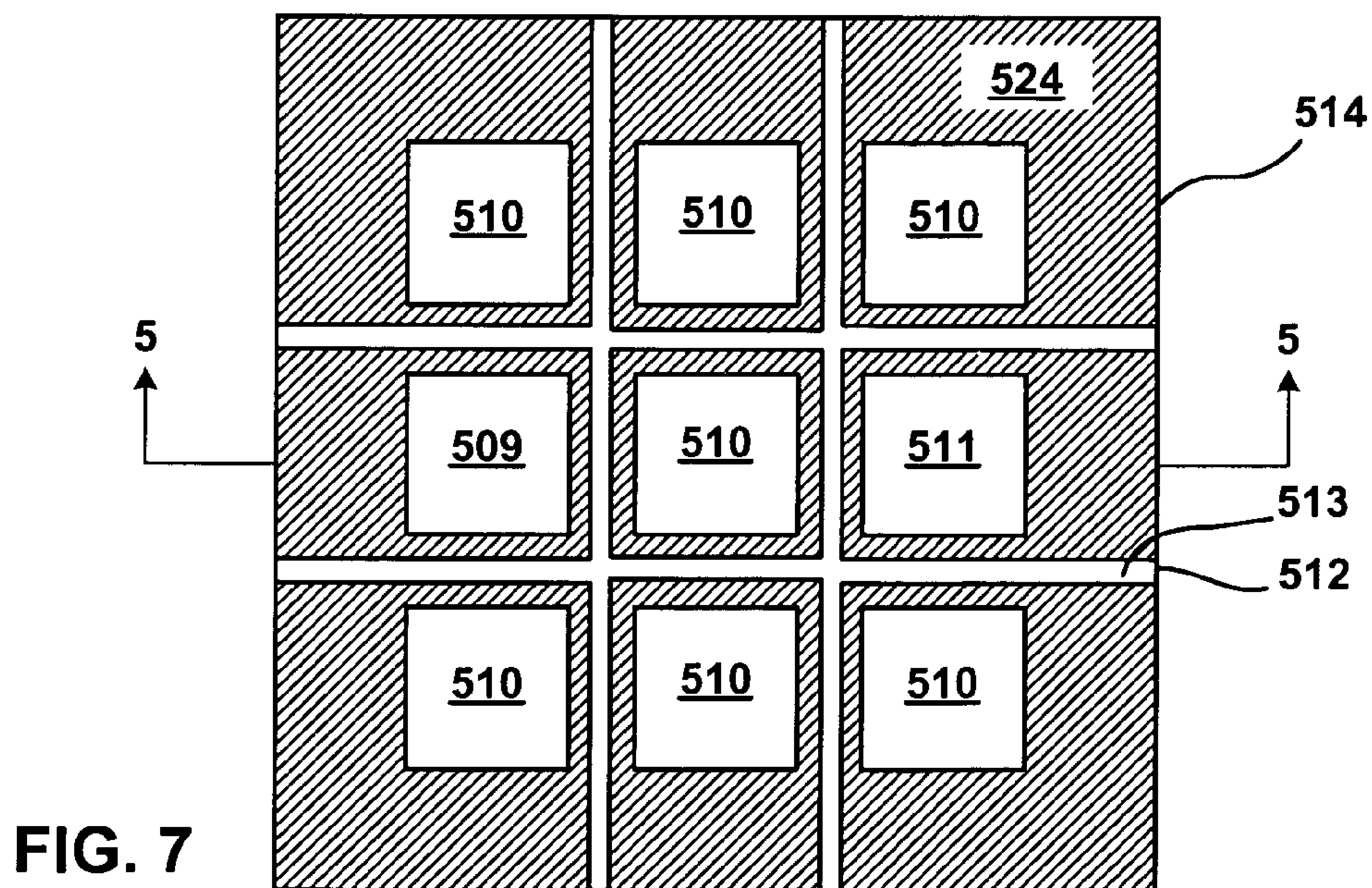


FIG. 7

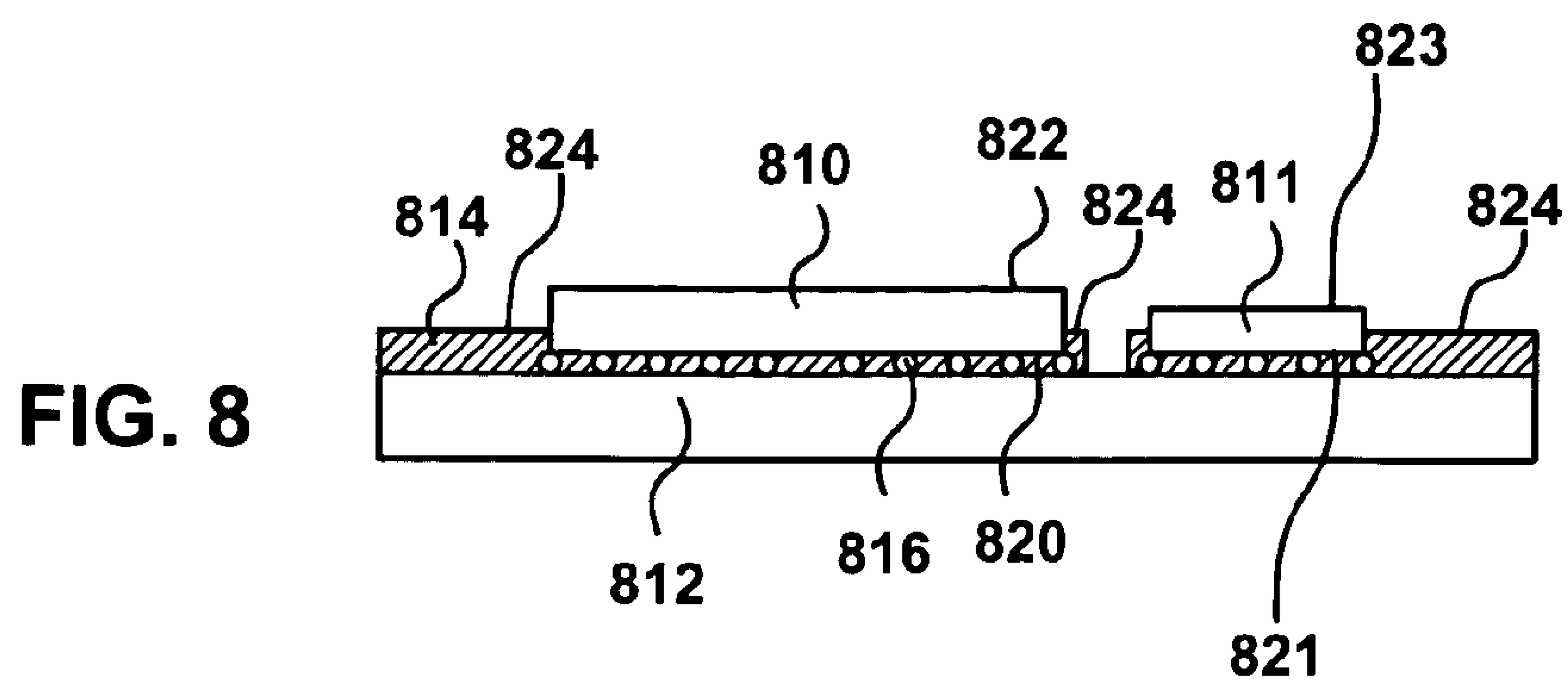


FIG. 8

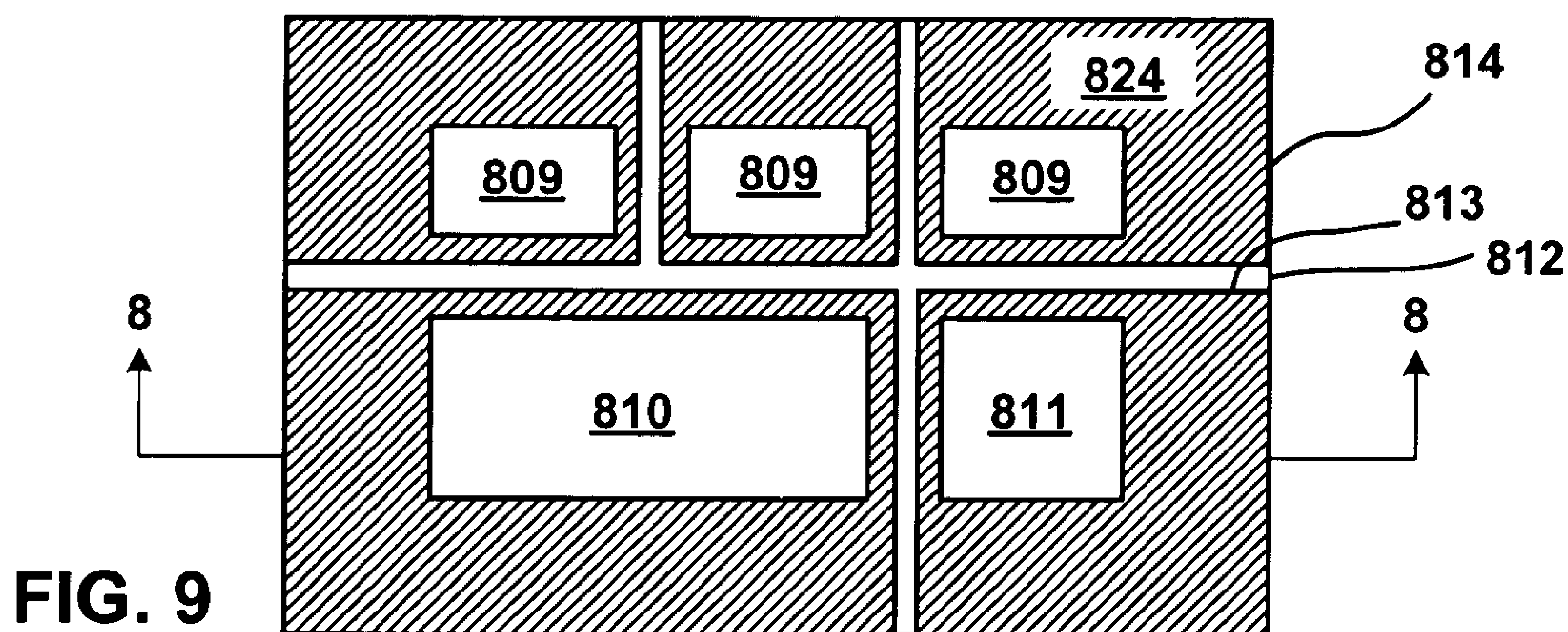


FIG. 9

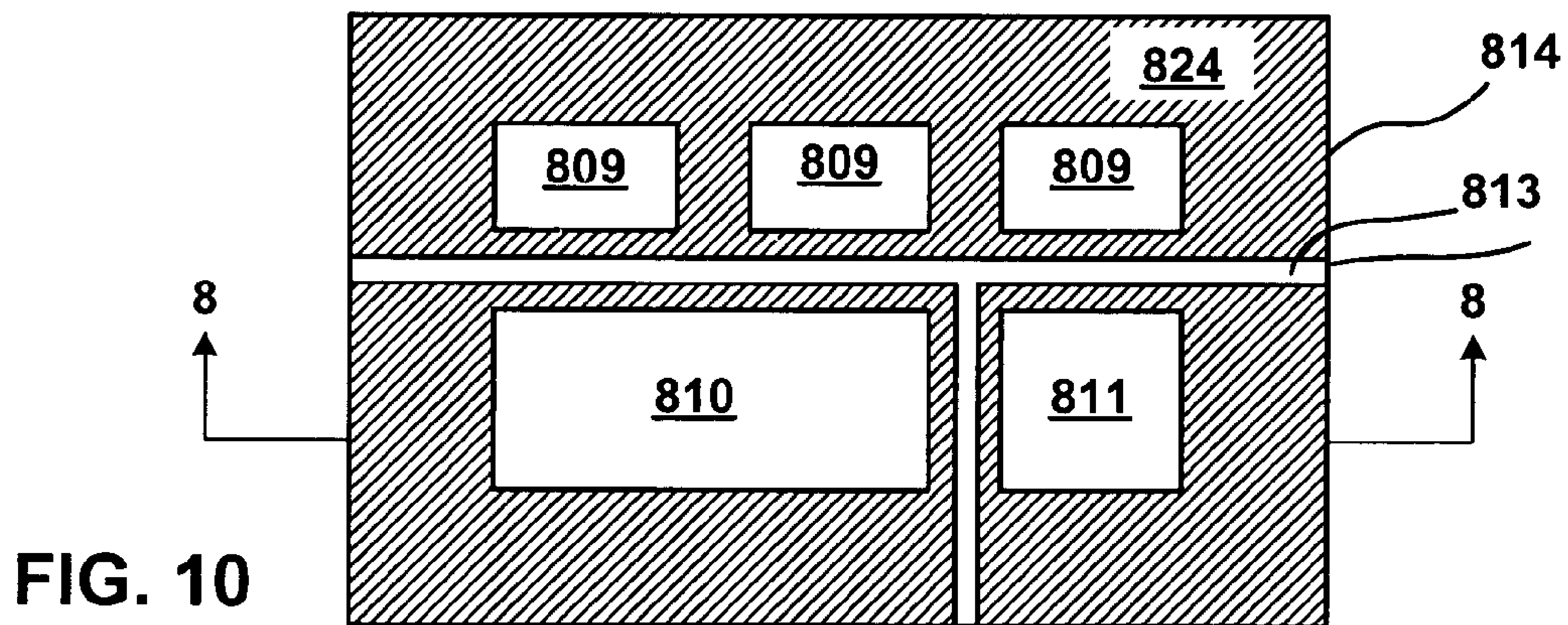


FIG. 10

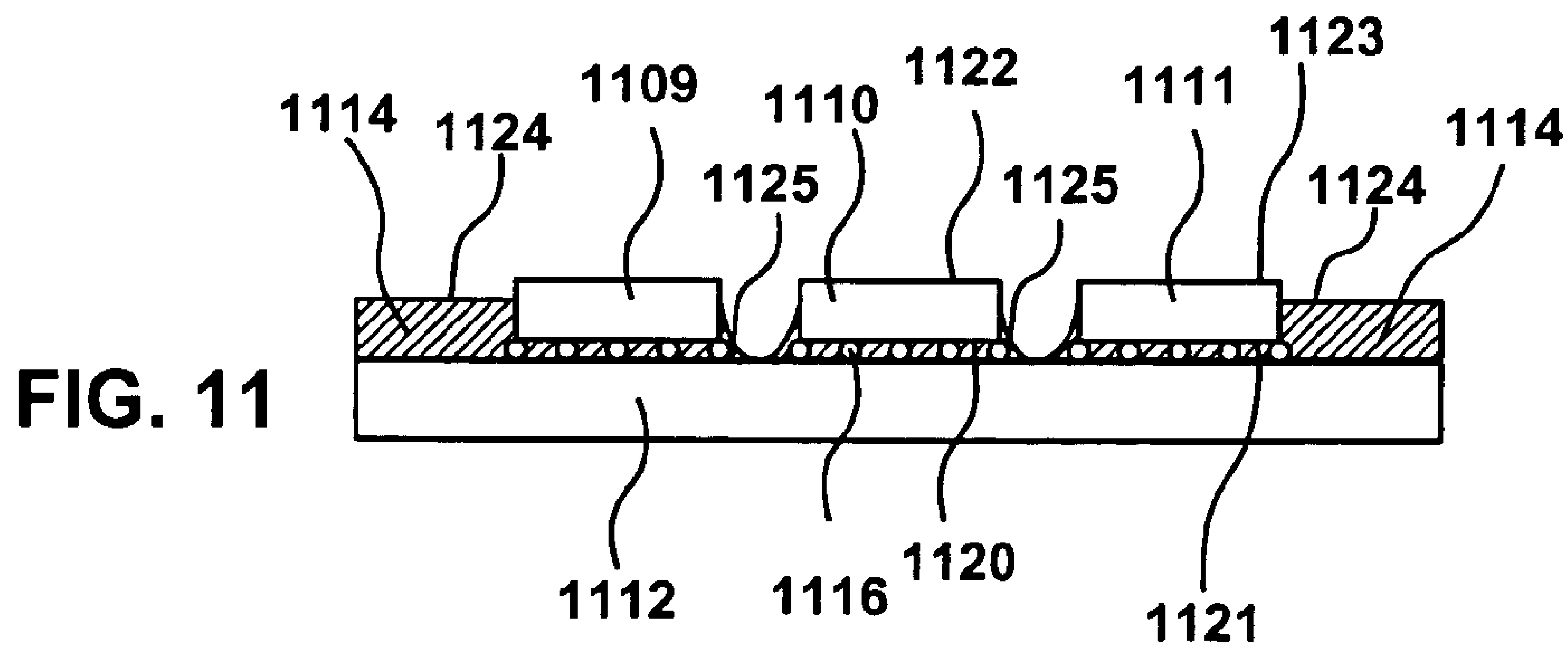


FIG. 11

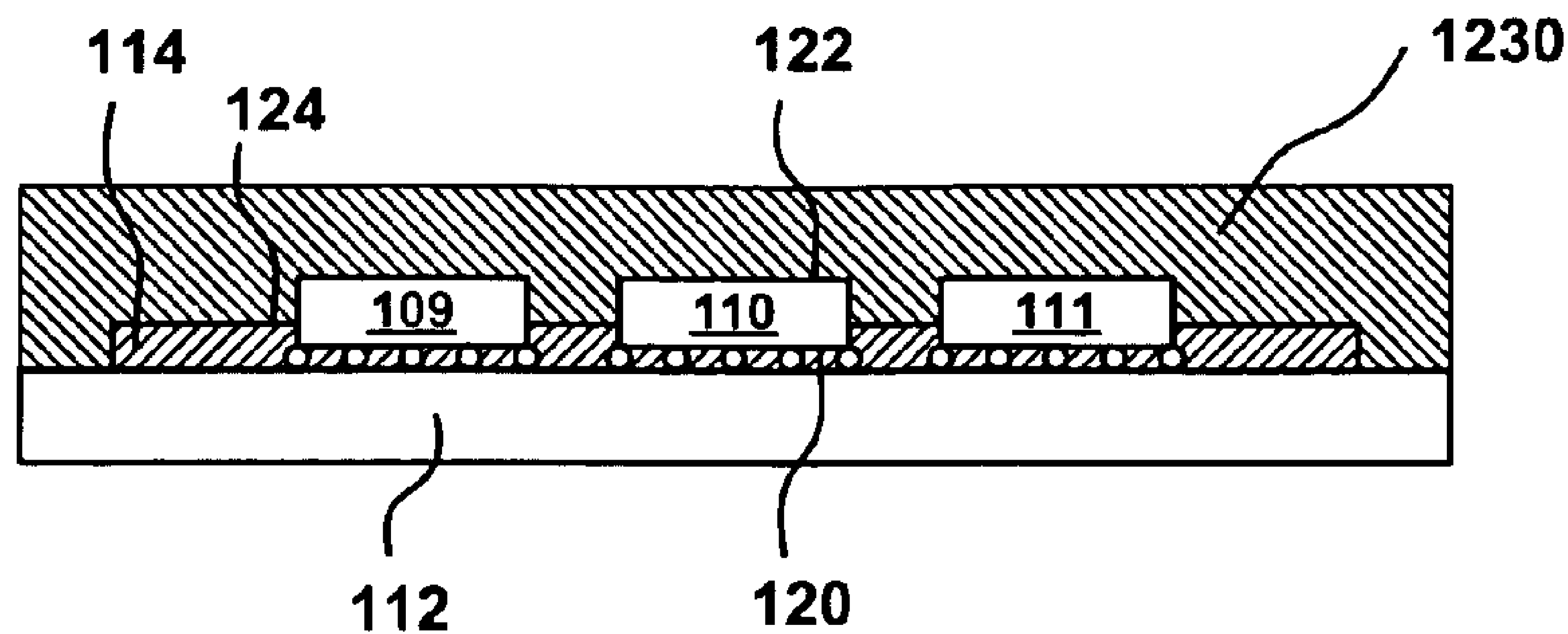


FIG. 12

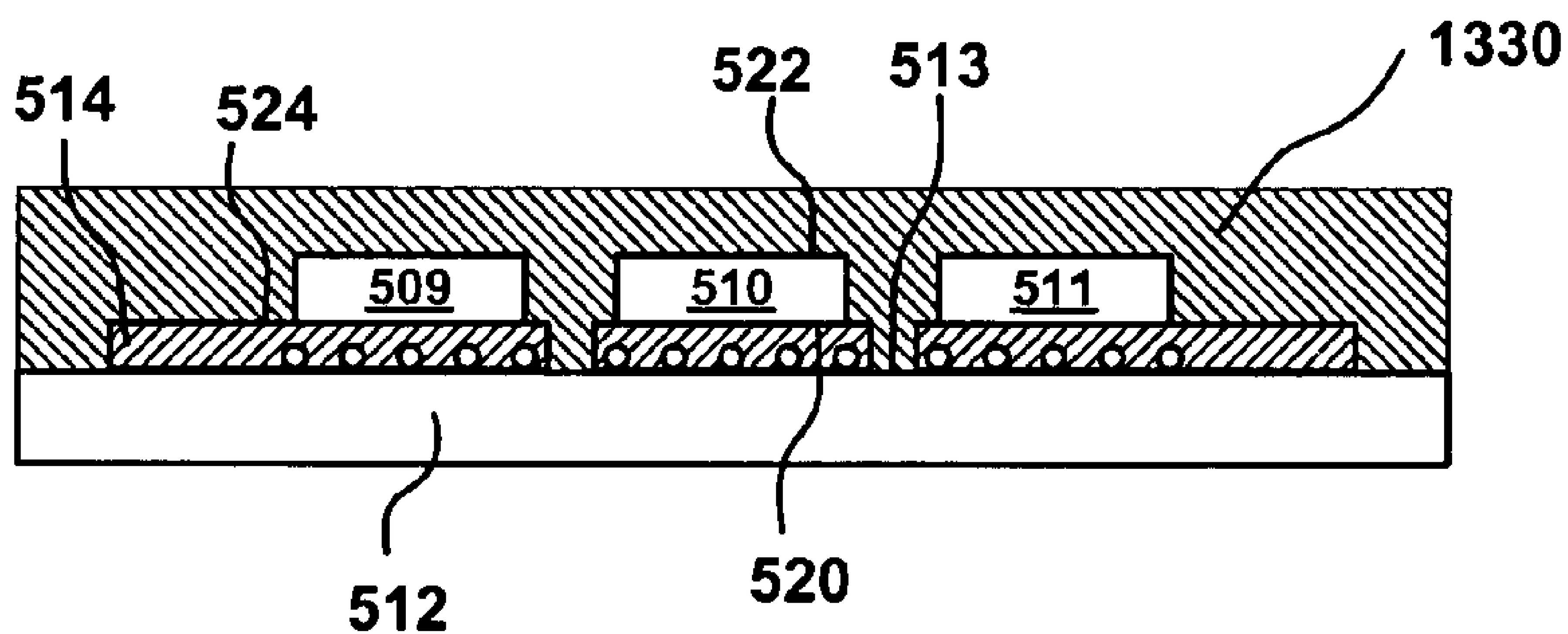


FIG. 13

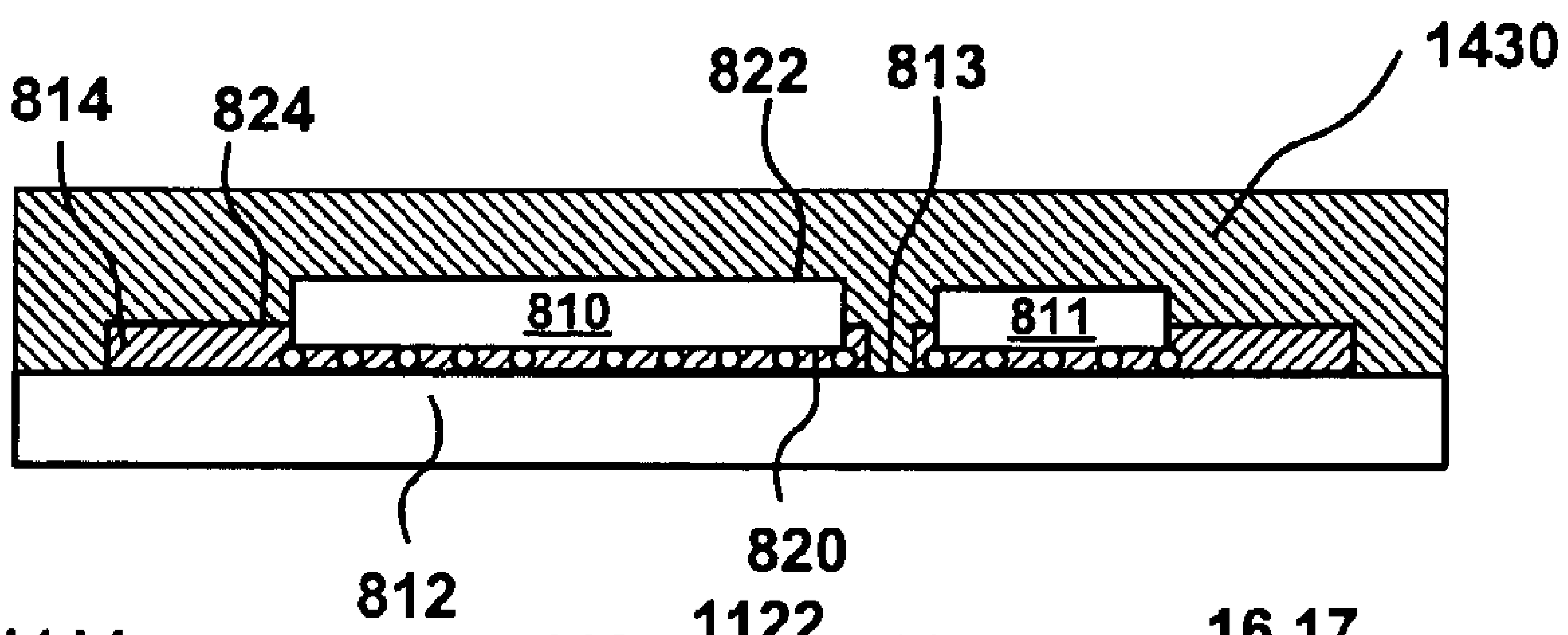


FIG. 14

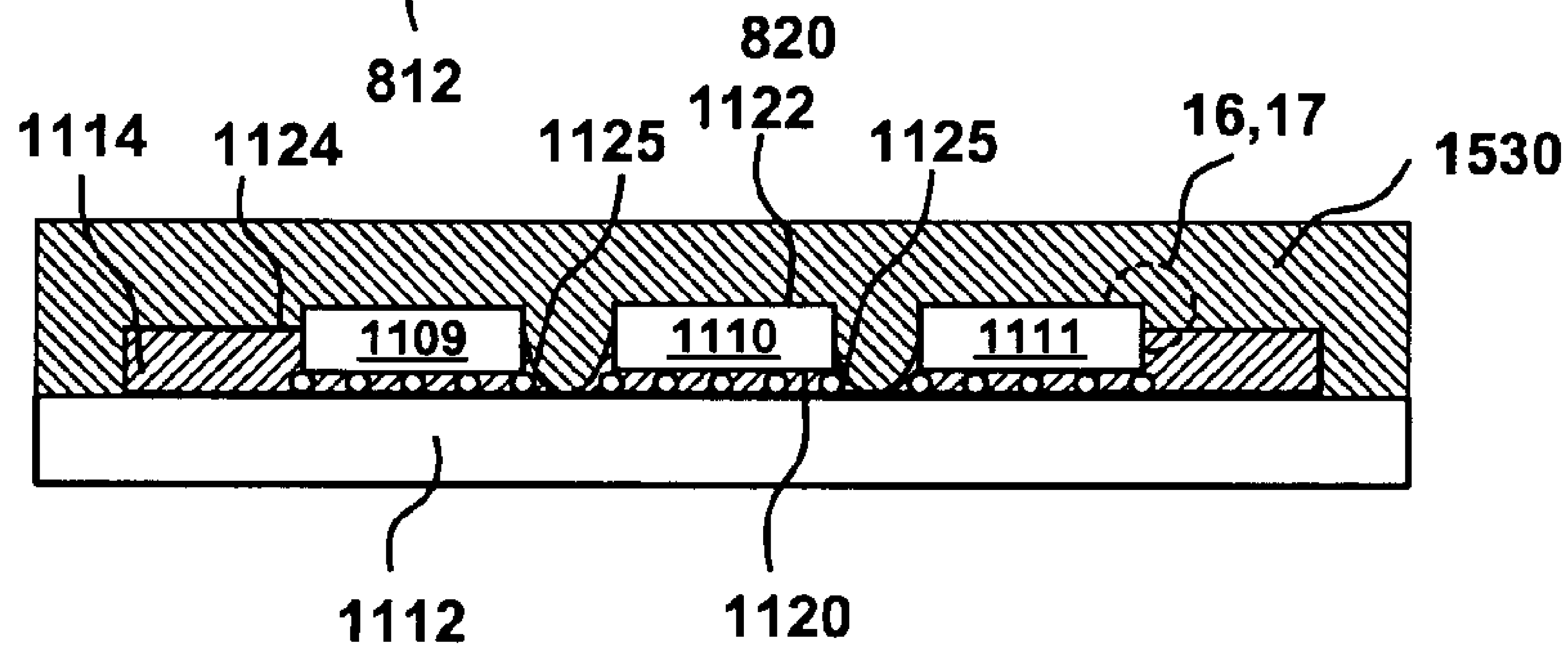


FIG. 15

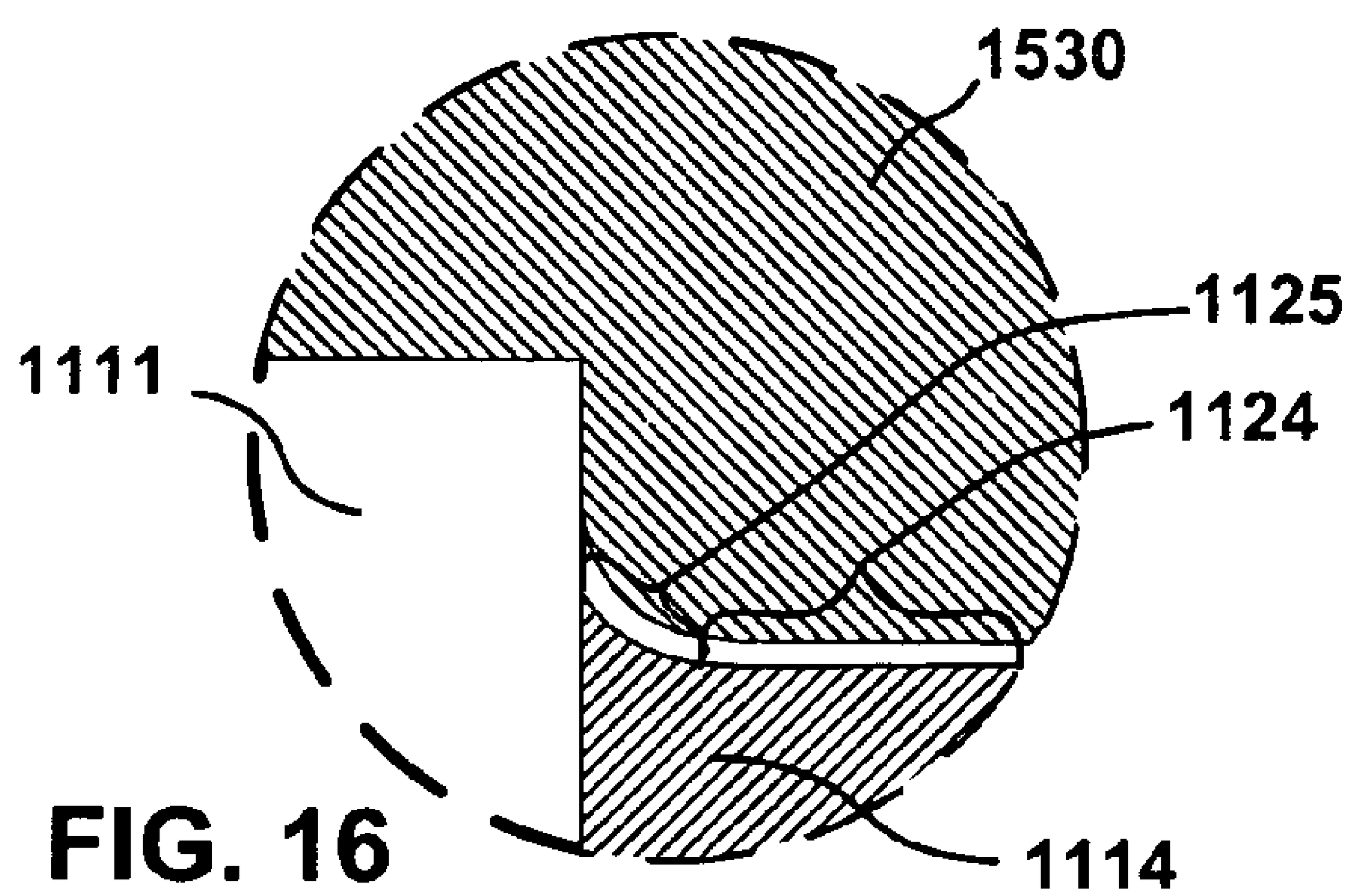


FIG. 16

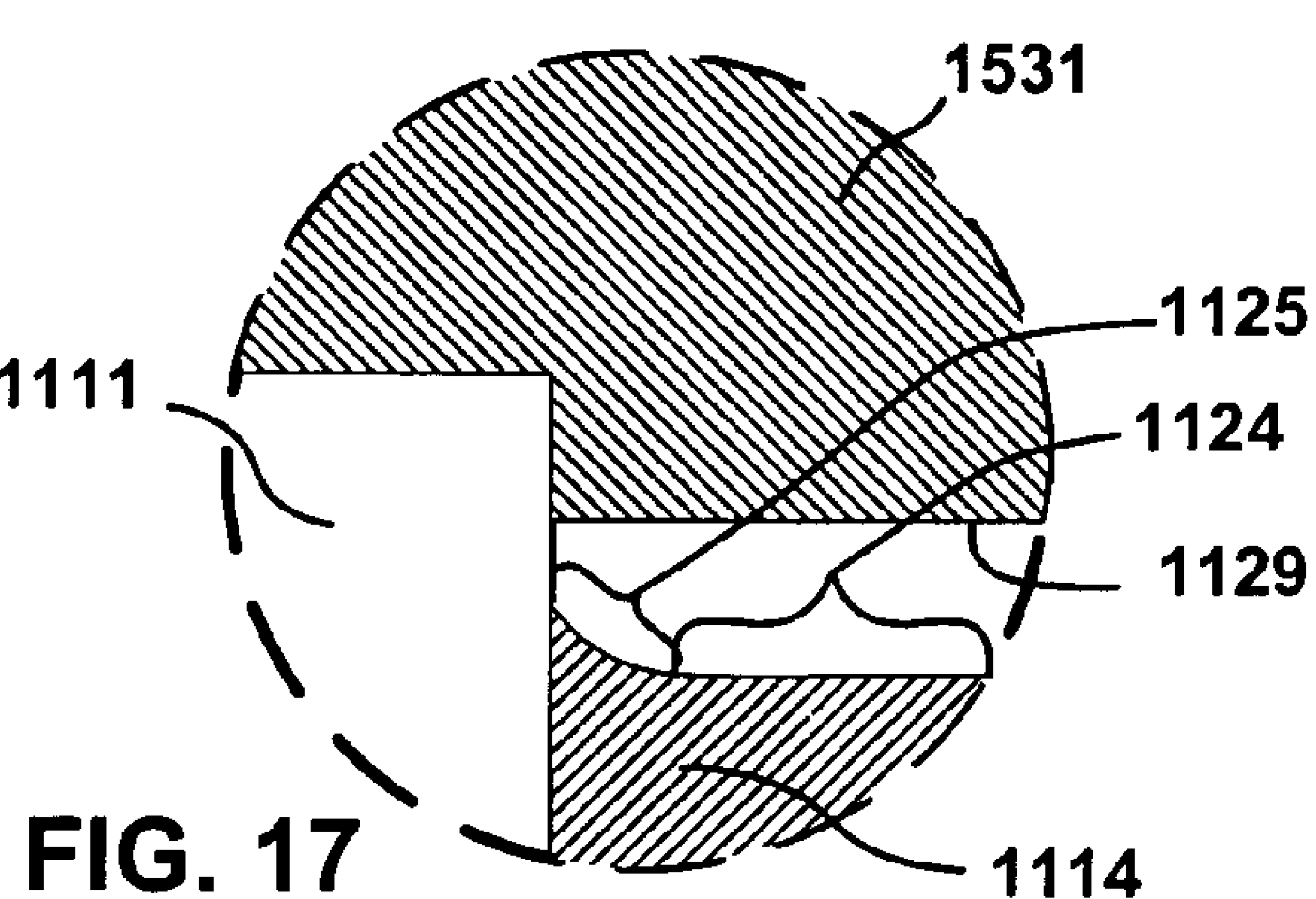


FIG. 17

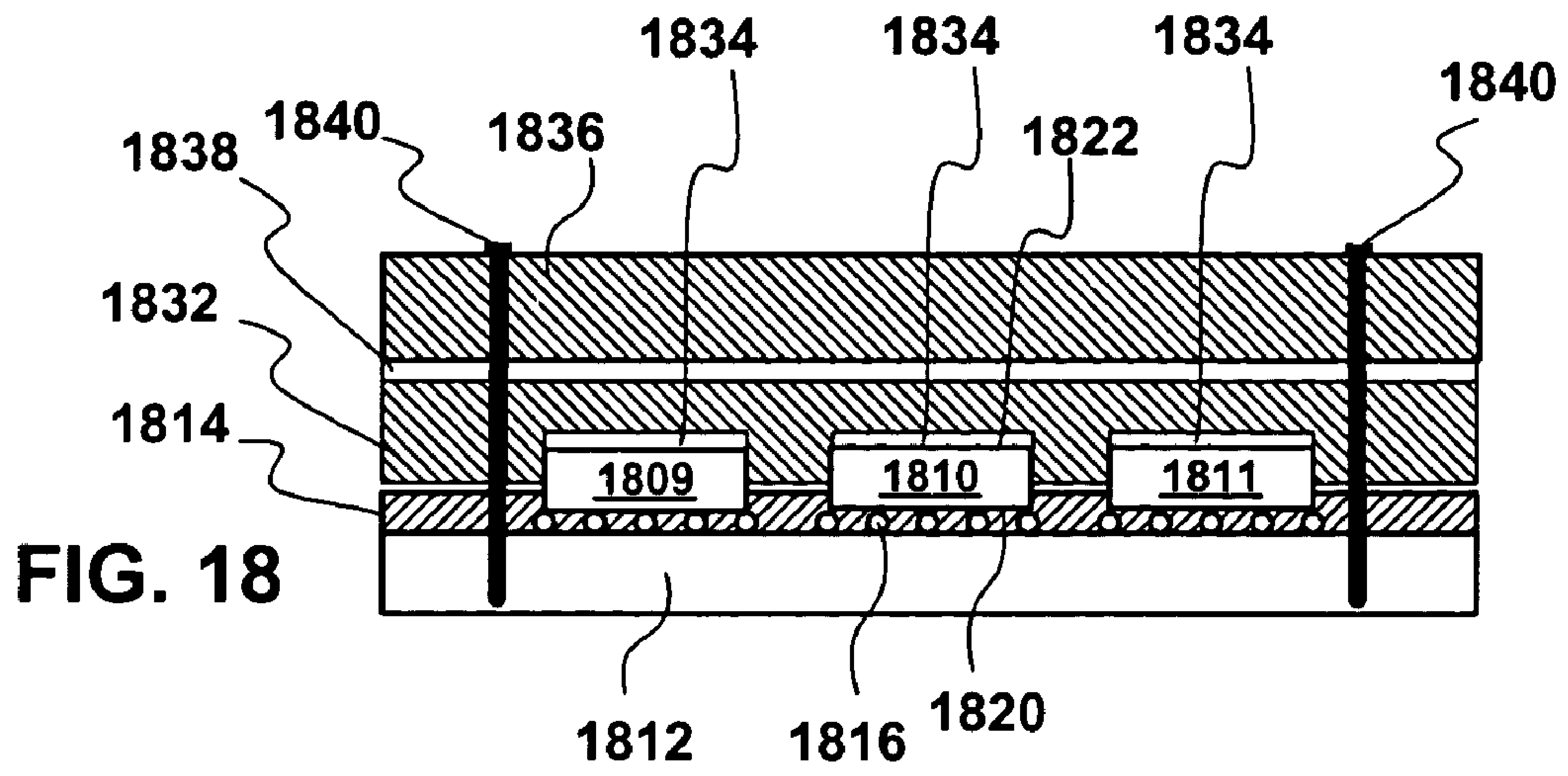


FIG. 18

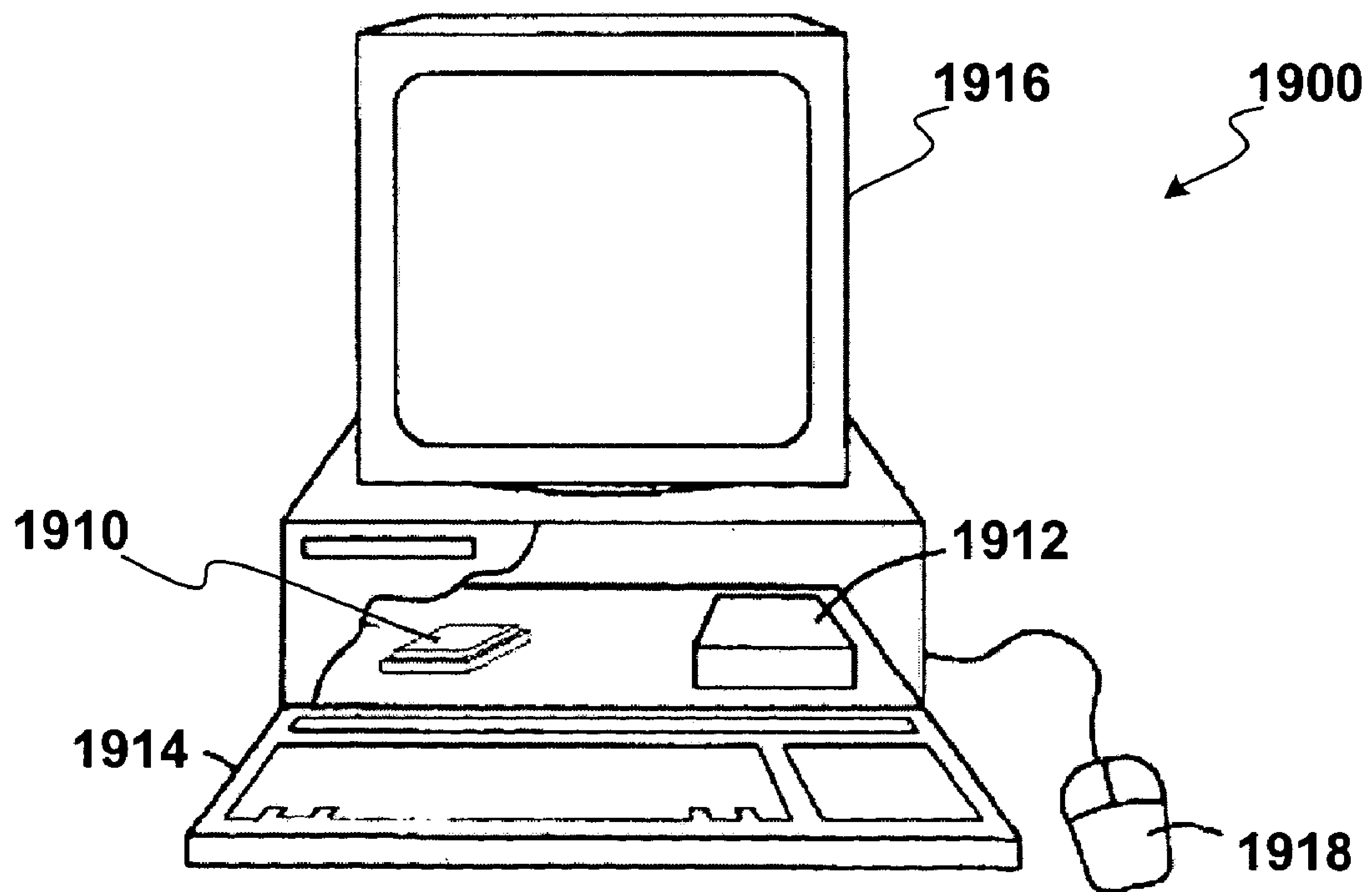


FIG. 19

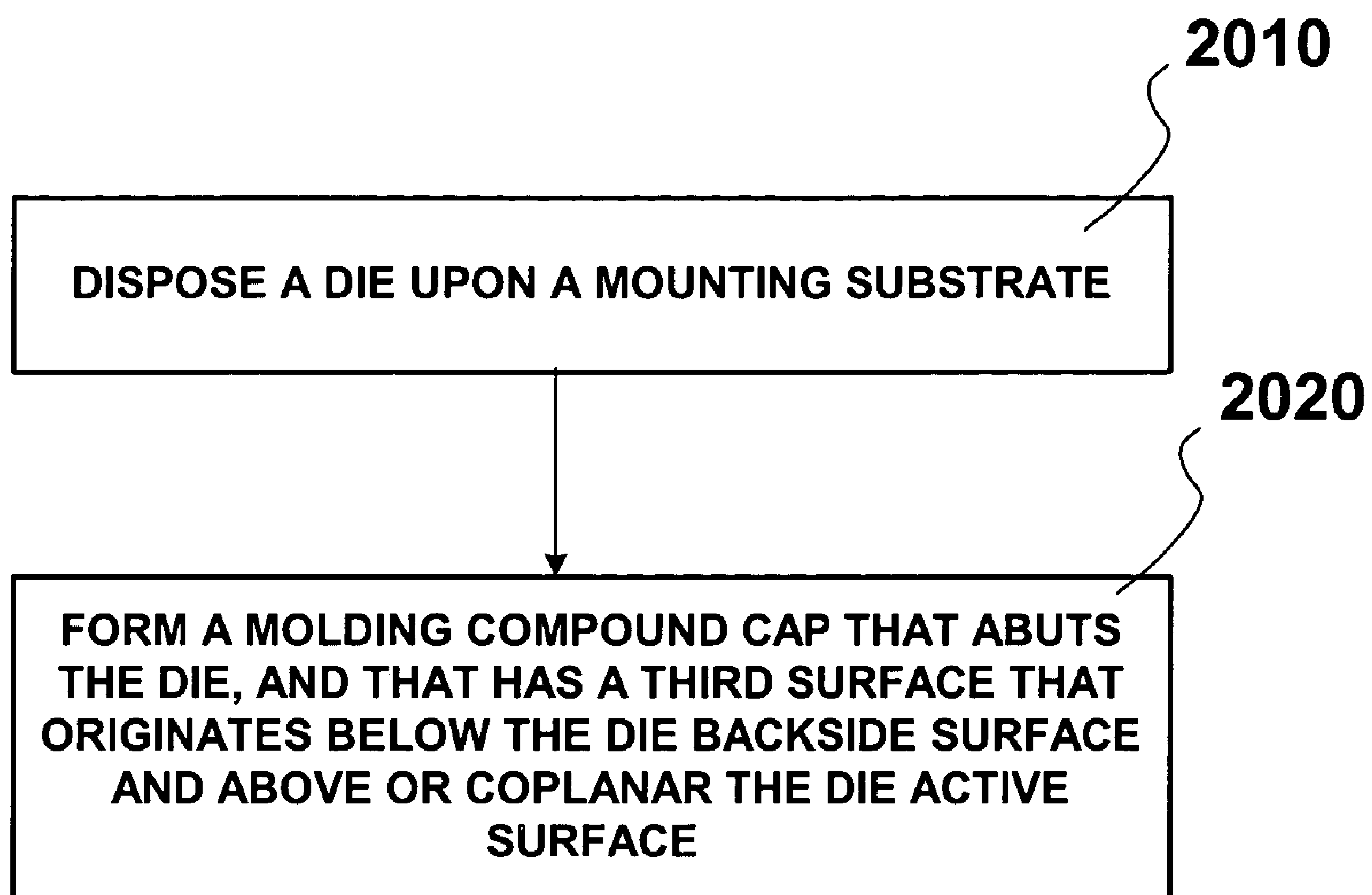


FIG. 20

MOLD COMPOUND CAP IN A FLIP CHIP MULTI-MATRIX ARRAY PACKAGE AND PROCESS OF MAKING SAME

BACKGROUND INFORMATION

1. Technical Field

Disclosed embodiments relate to an article that includes a mounted semiconductor die disposed in a molding compound cap. The molding compound cap exposes a portion of the die.

2. Description of Related Art

An integrated circuit (IC) die is often fabricated into a processor, a digital signal processor (DSP), and other devices for various tasks. The increasing power consumption of such dice results in tighter thermal budgets for a thermal solution design when the die is employed in the field. Accordingly, a thermal interface is often needed to allow the die to reject heat more efficiently. Various solutions have been used to allow the processor to efficiently reject heat.

During the process of encapsulating a microelectronic device, such as a die, in molding compound, the die is often placed inside of a mold, and encapsulation material is injected into the mold cavity. Because of the current molding process, molding compound often "flashes" onto the backside of a die. The flashing phenomenon occurs frequently for a flip-chip configuration where the active surface of the die is presented against a mounting substrate such as a printed wiring board, a mother board, a mezzanine board, an expansion card, or others. The flashing of molding compound upon the back surface of the die creates problems in heat management such that the back surface often must be processed to clean off the flashing of the molding compound.

An article includes a die in a molding compound. Because of thermal cycling of a die in the molding compound, where the molding compound and the backside surface of the die share a co-planar surface, excessive stress is formed at the backside comers of the die. These stresses can damage the die or its package such that a lower fabrication yield can result, or field failures of the article can result.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the manner in which embodiments are obtained, a more particular description of various embodiments briefly described above will be rendered by reference to the appended drawings. These drawings depict embodiments that are not necessarily drawn to scale and are not to be considered to be limiting of its scope. Some embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

FIG. **1** is a side cross-section of a package according to an embodiment;

FIG. **2** is a detail section taken along the line **2-2** from FIG. **1** according to an embodiment;

FIG. **3** is a detail section taken along the line **2-2** from FIG. **1** according to an embodiment;

FIG. **4** is a detail section taken along the line **2-2** from FIG. **1** according to an embodiment;

FIG. **5** is a side cross-section of a package according to an embodiment;

FIG. **6** is a top plan of the package depicted in FIG. **1** according to an embodiment;

FIG. **7** is a top plan of the package depicted in FIG. **5** according to an embodiment;

FIG. **8** is a side cross-section of a package according to an embodiment;

FIG. **9** is a top plan of the package depicted in FIG. **8** according to an embodiment;

FIG. **10** is a top plan of the package depicted in FIG. **8** according to an alternative embodiment;

FIG. **11** is a side cross-section of a package according to an embodiment;

FIG. **12** is a side cross-section of the package depicted in FIG. **1** during processing according to an embodiment;

FIG. **13** is a side cross-section of the package depicted in FIG. **5** during processing according to an embodiment;

FIG. **14** is a side cross-section of the package depicted in FIG. **8** during processing according to an embodiment;

FIG. **15** is a side cross-section of the package depicted in FIG. **11** during processing according to an embodiment;

FIG. **16** is a detail section taken from FIG. **15** according to an embodiment;

FIG. **17** is a detail section taken from FIG. **15** according to an alternative embodiment;

FIG. **18** is a side cross-section of a package according to an embodiment;

FIG. **19** is a depiction of a computing system according to an embodiment; and

FIG. **20** is a process flow diagram according to various embodiments.

DETAILED DESCRIPTION

The following description includes terms, such as upper, lower, first, second, etc. that are used for descriptive purposes only and are not to be construed as limiting. The embodiments of a device or article described herein can be manufactured, used, or shipped in a number of positions and orientations. The terms "die" and "processor" generally refer to the physical object that is the basic workpiece that is transformed by various process operations into the desired integrated circuit device. A board is typically a resin-impregnated fiberglass structure that acts as a mounting substrate for the die. A die is usually singulated from a wafer, and wafers may be made of semiconducting, non-semiconducting, or combinations of semiconducting and non-semiconducting materials.

Reference will now be made to the drawings wherein like structures are provided with like reference designations. In order to show the structure and process embodiments most clearly, the drawings included herein are diagrammatic representations of embodiments. Thus, the actual appearance of the fabricated structures, for example in a photomicrograph, may appear different while still incorporating the essential structures of embodiments. Moreover, the drawings show only the structures necessary to understand the embodiments. Additional structures known in the art have not been included to maintain the clarity of the drawings.

FIG. **1** is a side cross-section of a package according to an embodiment. The package includes a first die **110** that is disposed upon a mounting substrate **112**. The first die **110** is partially encapsulated in a molding compound cap **114** that abuts the first die **110**. The first die **110** is electronically coupled to the mounting substrate **112** through a bump **116** that is, by way of non-limiting example, a metal ball.

The first die **110** includes a first die active first surface **120** and a first die backside second surface **122**. One dimension of the article depicted in FIG. **1** includes a die height (DH) that is the vertical difference between the first die backside second surface **122** and the upper surface **113** of the mounting substrate **112**. Another parameter of the package, the

die-standoff height (DSH), is a measurement of the vertical difference in height between the first die active first surface **120** and the upper surface **113** of the mounting substrate **112**. Another parameter of the package depicted in FIG. **1**, the molding-compound height (MCH), is a measurement of the vertical difference between the third surface **124** of the molding compound cap **114** and the upper surface **113** of the mounting substrate **112**.

FIG. **1** also depicts a second die **111** that is disposed upon the mounting substrate **112**. The second die **111** includes a second die active first surface **121** and a second die backside second surface **123**. It is also depicted in this embodiment that the molding compound cap **114** abuts the second die **111** as well as the first die **110**. In FIG. **1**, a last die **109** is also depicted as disposed over the mounting substrate **112** and is likewise abutted by the molding compound cap **114**. In the embodiment depicted in FIG. **1**, the molding compound cap **114** is continuous and contiguous to the first die **110**, the second die **111**, and the last die **109**.

FIG. **2** is a detail section taken along the line **2-2** from FIG. **1** according to an embodiment. A first die **210** is disposed over the mounting substrate **112** (FIG. **1**) and is mounted in a molding compound cap **214** similar to the depiction in FIG. **1**. Additionally, a bump **216** enables electronic coupling between the first die **210** and the mounting substrate **112**. The first die **210** also is illustrated with the first die active first surface **220** and the first die backside second surface **222**. The molding compound cap **214** includes a third surface that includes a substantially planar portion **224** and a substantially curvilinear portion (hereinafter "third surface **224**, **225**) that originates substantially above the first die active first surface **220** and below the first die backside second surface **222**. A meniscus **225** portion of the third surface **224**, **225** forms a portion of the molding compound cap **214**. Accordingly, the meniscus **225** is that portion of the molding compound cap **214** that originates substantially above the first die active first surface **220** and below the first die backside second surface **222**.

In the embodiment depicted in FIG. **2**, the third surface **224**, **225** also has a metric that is a measurement of the distance between the substantially planar portion of the third surface **224** and the first die active first surface **220**. This distance is referred to as the molding compound cap encroachment **226**. The molding compound cap encroachment **226** can be quantified that portion of the die height that has been covered by the molding compound cap **214**, as a percentage of the die height. For example, the molding compound cap encroachment **226** appears to be about 25% of the die height. The die height is the distance between the first die active first surface **220** and the first die backside second surface **222**. In any event, the molding compound cap encroachment **226** is a fraction of the total die height.

FIG. **3** is a detail section that can be taken along the line **2-2** from FIG. **1** according to an embodiment. A first die **310** is disposed over a mounting substrate (not pictured) and is mounted in a molding compound cap **314** similar to the depiction in FIG. **1**. Additionally, a bump **316** enables electronic coupling between the first die **310** and the mounting substrate (not pictured). The first die **310** also is illustrated with the first die active first surface **320** and the first die backside second surface **322**. The molding compound cap **314** includes a third surface **324**, **325** that originates substantially above the first die active first surface **320** and below the first die backside second surface **322**. A meniscus **325** forms a portion of the molding compound cap **314**. Accordingly, the meniscus **325** is that portion of the molding compound cap **314** that originates substantially above the first die active first surface **320** and below the first die backside second surface **322**.

In the embodiment depicted in FIG. **3**, the third surface **324**, **325** also has the molding compound cap encroachment **326** metric. In FIG. **3**, the molding compound cap encroachment **326** appears to be about 80% of the die height.

In one embodiment, a particulate material **315** is interspersed with the molding compound cap **314**. In one embodiment, the particulate material **315** is a graphite fiber. In one embodiment, the particulate material **315** is a diamond powder. In one embodiment, the particulate material **315** is a silica filler. In one embodiment, the the particulate material **315** includes inorganics that are metallic in an organic matrix of the molding compound cap **314**. In this embodiment, the overall coefficient of thermal conductivity for the molding compound cap **314** and the particulate material **315** is in a range from about 0.1 W/m-K to less than or equal to about 600 W/m-K. In one embodiment, the particulate material **315** includes inorganics that are dielectrics in an organic matrix of the molding compound cap **314**. In this embodiment, the overall coefficient of thermal conductivity for the molding compound cap **314** and the particulate material **315** is in a range from about 10 W/m-K to about 90 W/m-K.

Although the particulate material **315** is depicted as angular and eccentric shapes, in one embodiment, the particulate material **315** can be other shapes. In one embodiment, the particulate material **315** is a substantially spherical powder that has an average diameter in a range from about 0.1 micron to about 100 micron. In one embodiment, the eccentricity of the particulate material **315**, as measured by a ratio of the major diagonal axis to the minor diagonal axis, is in a range from about 1 to about 10. In one embodiment, the eccentricity is greater than 10.

It can now be appreciated that the particulate material **315** that appears in the embodiments depicted in FIG. **3** can be present in any embodiment of a molding compound cap as set forth in this disclosure.

FIG. **4** is a detail section that can be taken along the line **2-2** from FIG. **1** according to an embodiment. A first die **410** is disposed over a mounting substrate (not pictured) and is mounted in a molding compound cap **414** similar to the depiction in FIG. **1**. Additionally, a bump **416** enables electronic coupling between the first die **410** and the mounting substrate (not pictured). The first die **410** also is illustrated with the first die active first surface **420** and the first die backside second surface **422**. The molding compound cap **414** includes a third surface **424**, **425** that originates substantially above the first die active first surface **420** and below the first die backside second surface **422**. A meniscus **425** portion of the third surface **424**, **425** forms a portion of the molding compound cap **414**. Accordingly, the meniscus **425** is that portion of the molding compound cap **414** that originates substantially above the first die active first surface **420** and below the first die backside second surface **422**.

In the embodiment depicted in FIG. **4**, the third surface **424**, **425** also has the molding compound cap encroachment **426** metric. In FIG. **4**, the molding compound cap encroachment **426** appears to be a negligible amount of the die height. The substantially planar portion **424** of the third surface **424**, **425** is substantially co-planar with the first die active first surface **420**. The meniscus **425**, however, originates at a position that is substantially above the first die active first surface **420** and below the first die backside second surface **422**.

By review of FIGS. **2**, **3**, and **4**, the molding compound cap encroachments **226**, **326**, and **426**, respectively, are depicted as about 25%, 80%, and 0%. Any percentage of the die height, however, is contemplated as an embodiment, so long as the percentage is a fraction of 100% including zero percent.

FIG. **5** is a side cross-section of a package according to an embodiment. A first die **510** is disposed upon a mounting substrate **512**, and a molding compound cap **514** abuts the first die **510**. A bump **516** couples the first die **510** to the mounting substrate **512**. The first die **510** includes a first die active first surface **520** and a first die backside second surface **522**.

The molding compound cap **514** includes a third surface **524** that originates substantially above the first die active first surface **520** and below the first die backside second surface **522**. Additionally, the molding compound cap **514** is segmented as depicted in FIG. **5** such that it exposes the mounting substrate **512** by revealing an upper surface **513** of the mounting substrate **512**. In addition to the first die **510**, FIG. **5** depicts a second die **511** that is disposed upon the mounting substrate **512** and includes a second die active first surface **521** and a second die backside second surface **523**. The molding compound cap **514**, although segmented, also abuts the second die. As depicted in FIG. **5**, the upper surface **513** of the mounting substrate **512** is exposed because of the segmentation of the molding compound cap **514**. In any event, the molding compound cap **514** includes a third surface **524** that originates substantially above the respective active first surfaces **520**, **521** of the first and second dice and below the respective backside second surfaces **522**, **523** of the first and second dice. In FIG. **5**, a last die **509** is also depicted as disposed over the mounting substrate **512** and is likewise abutted by the molding compound cap **514**. In the embodiment depicted in FIG. **5**, the molding compound cap **514** is segmented, but each portion of the segmented molding compound cap **514** is substantially contiguous to the first die **510**, the second die **511**, and the last die **509**.

FIG. **6** is a top plan view of the package depicted in FIG. **1** according to an embodiment. FIG. **6** represents in one embodiment a multi-matrix array package according to an embodiment. A plurality of dice includes a first die **110**, a second die **111**, and a last die **109**. In an embodiment, the first die **110**, the second die **111**, and the last die **109** represent multiple occurrences of the same die. As depicted in FIG. **6**, the molding compound cap **114** abuts all of the dice as depicted.

FIG. **7** is a top plan view of the package depicted in FIG. **5** according to an embodiment. FIG. **7** represents in one embodiment a multi-matrix array package according to an embodiment. A plurality of dice includes a first die **510**, a second die **511**, and a last die **509**. In an embodiment, the first die **510**, the second die **511**, and the last die **509** represent multiple occurrences of the same die. As depicted in FIG. **7**, the molding compound cap **514** abuts all of the dice as depicted. Additionally, the mounting substrate **512** is exposed at its upper surface **513** because of the segmentation of the molding compound cap **514**. Additionally, the third surface **524**, that is the upper surface of the molding compound cap **514**, is depicted in FIG. **7**. In the embodiment depicted in FIG. **7**, each occurrence of a die, whether it is the first die **510**, the second die **511**, or the last die **509**, is segmented in a discrete unit separate from each other die and its accompanying occurrence of abutting molding compound cap **514**.

FIG. **8** is a side cross-section of a package according to an embodiment. A first die **810** is disposed upon a mounting substrate **812** and is mounted in a molding compound cap **814** that abuts the first die **810**. A bump **816** allows the die **810** to be coupled to the mounting substrate **812**. The first die **810** includes a first die active first surface **820** and a first die backside second surface **822**. The molding compound cap **814** includes a third surface **824** that originates substantially above the first die active first surface **820** and below the first die backside second surface **822**. In this embodiment, as in all other embodiments, a meniscus (not depicted) can be present according to the formation of the molding compound cap **814**. Accordingly, and as represented in other embodiments in this disclosure, the meniscus is that portion of the molding compound cap **814** that originates substantially above the first die active first surface **820** and below the first die backside second surface **822**.

FIG. **8** also depicts a second die **811** that is disposed above mounting substrate **812** and is embedded in the molding compound cap **814**. The second die **811** includes a second die active first surface **821** and a second die backside second surface **823**. Although the first die **810** and the second die **811** are of different sizes and shapes, the mounting scheme of this embodiment includes an exposed portion of the upper surface **813** of the mounting substrate **812** by discrete segmentation of the molding compound cap **814**.

An embodiment of a plurality of dice that are of different shapes and sizes includes a single molding compound cap that is not segmented. This embodiment can be realized, for example in FIG. **1**, by removing the dice **109**, **110**, **111**, and by replacing them with the dice **810**, **811** from FIG. **8**.

FIG. **9** is a top plan view of the package depicted in FIG. **8** according to an embodiment. FIG. **9** represents in one embodiment a multi-matrix array package according to an embodiment. A plurality of dice includes the first die **810**, the second die **811**, and the last die **809**. In an embodiment, the first die **810**, the second die **811**, and the last die **809** represent multiple occurrences of the same die. As depicted in FIG. **9**, the molding compound cap **814** abuts all of the dice as depicted.

FIG. **9** also depicts the mounting substrate **812** and shows that the upper surface **813** of the mounting substrate **812** is exposed between discrete segments of the molding compound cap **814**. Additionally, the third surface **824**, that is the upper surface of the molding compound cap **814**, is depicted in FIG. **9**. In the embodiment depicted in FIG. **9**, each occurrence of a die, whether it is the first die **810**, the second die **811**, or the last die **809**, is segmented in a discrete unit separate from each other die and its accompanying occurrence of abutting molding compound cap **814**.

In one embodiment, the chip package depicted in FIG. **9**, can include a main die such as a processor **810** that can be an application-specific integrated circuit (ASIC) and the second die **811** can be a specialized die such as a telecommunications and/or graphics device. By way of non-limiting example, the last die **809** as depicted in FIG. **9** can be at least one memory device. In one embodiment, the chip package depicted in FIG. **9** represents a wireless device technology such as a telephone, a personal data assistant, a personal computer, or a combination of two of the aforementioned devices.

Although the first die **810** and the second die **811** are depicted as having different die heights in FIG. **8**, one can read this disclosure and understand that one embodiment includes the first die **810** and the second die **811** having substantially equal heights. In one embodiment, the DH can be the same for the first die **810** and the second die **811**, but the DSH of each can be different.

FIG. **10** is a top plan view of the package depicted in FIG. **8** according to an alternative embodiment. FIG. **10** represents in one embodiment a multi-matrix array package according to an embodiment. A plurality of dice includes a first die **810**, a second die **811**, and a last die **809**. In an embodiment, the first die **810**, the second die **811**, and the last die **809** represent multiple occurrences of the same die. As depicted in FIG. **10**, the molding compound cap **814** abuts all of the dice as depicted.

FIG. **10** also depicts the mounting substrate **812** and shows that the upper surface **813** of the mounting substrate **812** is exposed between discrete segments of the molding compound cap **814**. Additionally, the third surface **824**, that is the upper surface of the molding compound cap **814**, is depicted in FIG. **10**. In the embodiment depicted in FIG. **10**, each occurrence of a die, whether it is the first die **810**, the second die **811**, or the last die **809**, is segmented in a discrete unit separate from each other die and its accompanying occurrence of abutting molding compound cap **814**.

In one embodiment, the chip package depicted in FIG. **10**, can include a main die such as a processor **810** that can be an application-specific integrated circuit (ASIC) and the second die **811** can be a specialized die such as a telecommunications and/or graphics device. By way of non-limiting example, the last die **809** as depicted in FIG. **10** can be at least one memory device. In one embodiment, the chip package depicted in FIG. **10** represents a wireless device technology such as a telephone, a personal data assistant, a personal computer, or a combination of two of the aforementioned devices.

Although the first die **810** and the second die **811** are depicted as having different die heights in FIG. **8**, one can read this disclosure and understand that one embodiment includes the first die **810** and the second die **811** having substantially equal heights. In one embodiment, the DH can be the same for the first die **810** and the second die **811**, but the DSH of each can be different.

In FIG. **10**, all of last dice **809** are encapsulated according to an embodiment in a single discrete occurrence of the molding compound cap **814**. In this embodiment, however, the first die **810** is discretely disposed in a separate occurrence of the molding compound cap **814**. Likewise, the second die **811** is discretely disposed in a separate occurrence of the molding compound cap **814**. One embodiment (not pictured) includes the configuration where all of last dice **809** are encapsulated together according to an embodiment in a single discrete occurrence of the molding compound cap **814**, and where the first die **810** and the second die **811** are discretely encapsulated separate from the last dice **809**, but the first die **810** and the second die **811** are encapsulated together in the molding compound cap **814**.

FIG. **11** is a side-cross section of a package according to an embodiment. A first die **1110** is disposed upon a mounting substrate **1112** and is encapsulated in a molding compound cap **1114** that abuts the first die **1110**. The first die **1110** is coupled to the mounting substrate **1112** through a bump **1116**. The first die **1110** includes a first die active first surface **1120** and a first die backside second surface **1122**. In FIG. **11**, the molding compound cap **1114** includes a substantially rectangular profile near the lateral edges of the package. Accordingly, the third surface **1124** is substantially planar.

FIG. **11** also depicts a second die **1111** and a last die **1109**. The second die **1111** includes a second die active first surface **1121** and a second die backside second surface **1123**. Between the first die **1110** and the second die **1111** the molding compound **1114** includes a fourth surface **1125** that is substantially curvilinear. The molding compound cap **1114** between the first die **1110** and the second die **1111** originates at each die substantially above the respective first and second die active first surfaces **1120**, **1121** and below the respective first and second die backside second surfaces **1122** and **1123**. A meniscus (not pictured) according to the various embodiments set forth in this disclosure, abuts the outer edges of the second die **1111** and the last die **1109**.

FIG. **12** is a side cross-section of a package such as the package depicted in FIG. **1** during processing according to an embodiment. During processing, the molding compound cap **114** is injected into the package between a mold chase **1230** and the mounting substrate **112**. In this embodiment, the mold chase **1230** is depicted as having a vertical profile that complements the profiles of the first die **110**, the second die **111**, and the last die **109** if more than one last die **109** is present. According to this embodiment, the problem of flashing, the phenomenon of molding compound leaking onto the backside second surface of the dice, is eliminated due to the vertical profile of the mold chase **1230**.

In one embodiment, processing includes injection molding or transfer molding with particulate fillers as set forth in this disclosure. In one embodiment, processing includes injection molding followed by in situ thermal curing or thermal partial curing by application of heat through the mold chase **1230**. After processing, the mold chase **1230** is removed, and the package substantially as it is depicted in FIGS. **1-4** results according to various embodiments.

FIG. **13** is a side cross-section of the package depicted in FIG. **5** during processing according to an embodiment. During processing, the molding compound cap **514** is injected into the package between a mold chase **1330** and the mounting substrate **512**. In this embodiment, the mold chase **1330** is depicted as having a vertical profile that complements the profiles of the first die **510**, the second die **511**, and the last die **509** if more than one last die **509** is present. Additionally, the profile of the mold chase **1330** leaves a portion of the upper surface **513** exposed. According to this embodiment, the problem of flashing is eliminated due to the vertical profile of the mold chase **1330**.

In one embodiment, processing includes injection molding or transfer molding with particulate fillers as set forth in this disclosure. In one embodiment, processing includes injection molding followed by thermal curing or thermal partial curing by application of heat through the mold chase **1330**. After processing, the mold chase **1330** is removed, and the package substantially as it is depicted in FIG. **5** results according to various embodiments. The mold chase **1330** includes in its vertical profile, a portion that substantially touches the upper surface **513** of the mounting substrate **512**. Accordingly, an exposed portion of the mounting substrate **512** and discrete segments of the molding compound cap **514** is the result when the mold chase is removed as is depicted in FIG. **5**.

FIG. **14** is a side cross-section of the package depicted in FIG. **8** during processing according to an embodiment. During processing, the molding compound cap **814** is injected into the package between a mold chase **1430** and the mounting substrate **812**. In this embodiment, the mold chase **1430** is depicted as having a vertical profile that complements the profiles of the first die **810**, the second die **811**, and the last die **809** if more than one last die **809** is present. According to this embodiment, the problem of flashing is eliminated due to the vertical profile of the mold chase **1430**. After processing, the mold chase **1430** is removed, and the package substantially as it is depicted in FIG. **8** results according to an embodiment. The mold chase **1430** includes in its vertical profile, a portion that substantially touches the

upper surface **813** of the mounting substrate **812**. Accordingly, an exposed portion of the mounting substrate **812** and discrete segments of the molding compound cap **814** is the result when the mold chase **1430** is removed as is depicted in FIG. **8**.

FIG. **15** is a side cross-section of the package depicted in FIG. **11** during processing according to an embodiment. During processing, the molding compound cap **1114** is injected into the package between a mold chase **1530** and the mounting substrate **1112**. In this embodiment, the mold chase **1530** is depicted as having a vertical profile that complements the profiles of the first die **1110**, the second die **1111**, and the last die **1109**. According to this embodiment, the problem of flashing is eliminated due to the vertical profile of the mold chase **1530**. After processing, the mold chase **1530** is removed, and the package substantially as it is depicted in FIG. **11** results according to an embodiment. The mold chase **1530** includes in its vertical profile, a portion that has imposed the curvilinear profile **1125** (FIG. **11**) that approaches the upper surface **1113** of the mounting substrate **1112**. Accordingly, an exposed portion of the mounting substrate **1112** will be the result when the mold chase is removed as is depicted in FIG. **11**.

The mold chase **1530** imposes both a rectangular profile upon the molding compound cap **1114** at the edges of the package and a curvilinear profile **1125** of the molding compound cap **1114** between the occurrence of the first die **1110** and the second die **1111** as well as between the first die **1110** and the last die **1109**. According to an embodiment, it can be understood that the profile of the molding compound cap **1114** includes both a substantially planar surface and a meniscus. In one embodiment, the substantially planar surface and meniscus include an upper surface **1124** as depicted in FIG. **11**, and as depicted in more detail in FIGS. **2-4**. In one embodiment, the meniscus includes the curvilinear surface **1125** as depicted in FIG. **11**. In any event, the meniscus is that portion of the molding compound cap **1114** that originates substantially above the first die active first surface **1120** and below the first die backside second surface **1122**.

FIG. **16** is a detail section taken from FIG. **15** according to an embodiment. The second die **1111** is depicted along with the mold chase **1530** and the molding compound cap **1114**. The meniscus **1125** of the third surface **1124** has been imposed by the shape of the mold chase **1530** where it abuts a lateral surface of the second die **1111**. In this embodiment, it is understood, that the meniscus **1125** is an "imposed meniscus." The meniscus **1125** is imposed by the shape of the mold chase **1530** where it abuts the edge of the second die **1111**.

FIG. **17** is a detail section taken from FIG. **15** according to an alternative embodiment. The second die **1111** has been over-molded by a mold chase **1531** that has a substantially planar lower profile **1129**. The occurrence of the meniscus **1125**, however, exists because of the wetting quality of the material of the molding compound cap **1114**. As the mold chase **1531** is lifted away from the package, or otherwise during the molding process, the meniscus **1125** forms by capillary action. Accordingly, the third surface **1124** and **1125** include a substantially planar surface **1124** and curvilinear surface **1125**. In this embodiment, the meniscus **1125** is referred to as a "capillary action meniscus."

FIG. **18** is a side cross-section of a package according to an embodiment. A first die **1810** is disposed upon a mounting substrate **1812** according to many of the various embodiments set forth in this disclosure. A second die **1811** is disposed upon the mounting substrate **1812** next to the first die **1810**. Similarly, a last die **1809** is disposed upon the mounting substrate **1812** next to the first die. A molding compound cap **1814** is depicted abutting the respective dice **1810**, **1811** and **1809**. The embodiment of the molding compound cap **1814** has the appearance of the embodiment of the molding compound cap **114** depicted in FIG. **1**. The molding compound cap **1814**, however, should be understood to include but not be limited to other embodiments. Examples include but are not limited to the molding compound cap **514** depicted in FIG. **5**, the molding compound cap **814** depicted in FIG. **8**, and the molding compound cap **1114** depicted in FIG. **11**. Other embodiments include but are not limited to the plan view embodiments depicted in this disclosure. By reading this disclosure, one of ordinary skill in the art can understand other configurations of a molding compound cap in a package according to an embodiment.

A heat spreader **1832** is disposed over the dice **1810**, **1811**, and **1809**. The heat spreader **1832** is set upon the back side second surfaces of the dice **1810**, **1811**, and **1809** and bonded with a thermal interface material (TIM) **1834**. The heat spreader **1832** along with the TIM **1834**, represent a thermal solution referred to as "TIM **1**." In one embodiment, the TIM **1838** and the heat spreader **1832** are referred to as an "enabling solution" that can have a stand-alone commercial applicability. In one embodiment, the TIM **1834** is indium (In). In one embodiment, the TIM **1834** is an indium-tin (InSn) alloy. In one embodiment, the TIM **1834** is an indium-silver (InAg) alloy. In one embodiment, the TIM **1834** is a tin-silver (SnAg) alloy. In one embodiment, the TIM **1834** is a tin-silver-copper (SnAgCu) alloy. In one embodiment, the TIM **1834** is a thermally conductive polymer.

Disposed above the heat spreader **1832** is a heat sink **1836**. The heat sink **1836** is bonded to the heat spreader **1832** with a TIM **1838**. The additional heat sink **1836** and the TIM **1838** are referred to as an enabling solution that can have a commercial applicability as what is referred to as "TIM **2**." The heat sink **1836** is depicted generically as a heat slug. The heat sink **1836**, however, can be any type of heat sink according to a specific application need, including a heat pipe, a fan, a skived heat sink, or others. In one embodiment, the heat sink **1836** is bolted or otherwise fastened to the heat spreader **1832** and optionally to the mounting substrate **1812** by a fastener **1840**. The fastener can be any type of connector such as a bolt, a screw, a nail, or others.

FIG. **19** is a depiction of a computing system **1900** according to an embodiment. One or more of the foregoing embodiments that includes a molding compound cap as disclosed herein may be utilized in a computing system, such as a computing system **1900** of FIG. **19**. The computing system **1900** includes at least one die (not pictured), which is enclosed in a microelectronic device package **1910**, a data storage system **1912**, at least one input device such as a keyboard **1914**, and at least one output device such as a monitor **1916**, for example. The computing system **1900** includes a die that processes data signals such as a microprocessor, available from Intel Corporation. In addition to the keyboard **1914**, the computing system **1900** can include another user input device such as a mouse **1918**, for example.

For the purposes of this disclosure, a computing system **1900** embodying components in accordance with the claimed subject matter may include any system that utilizes a microelectronic device package, which may include, for example, a data storage device such as dynamic random access memory, polymer memory, flash memory, and phase-change memory. The microelectronic device package can

also include a die that contains a digital signal processor (DSP), a micro controller, an application specific integrated circuit (ASIC), or a microprocessor.

Embodiments set forth in this disclosure can be applied to devices and apparatuses other than a computing system of a traditional computer. For example, a die can be packaged with an embodiment of the molding compound cap and placed in a portable device such as a wireless communicator or a hand-held such as a personal data assistant and the like. Another example is a die that can be packaged with an embodiment of the molding compound cap and placed in a vehicle such as an automobile, a locomotive, a watercraft, an aircraft, or a spacecraft.

FIG. **20** is a process flow diagram according to various embodiments. At **2010**, a die is disposed upon a mounting substrate. At **2020**, the molding compound cap is formed abutting the die. Forming the molding compound cap includes forming a highest surface that is above the active surface and below the backside surface. In one embodiment, the process can proceed by injection molding. In one embodiment, the process can proceed by injection molding a molding compound cap, followed by pick-and-place disposing the molding compound cap over a die followed by optional curing.

It is emphasized that the Abstract is provided to comply with 37 C.F.R. §1.72(b) requiring an Abstract that will allow the reader to quickly ascertain the nature and gist of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims.

In the foregoing Detailed Description, various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments of the invention require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate preferred embodiment.

It will be readily understood to those skilled in the art that various other changes in the details, material, and arrangements of the parts and method stages which have been described and illustrated in order to explain the nature of this invention may be made without departing from the principles and scope of the invention as expressed in the subjoined claims.

What is claimed is:

1. A processing system comprising:

a mold chase including a profile that is capable of causing molding cap compound to originate on a die at a die height that is substantially above the die active surface and below the die backside second surface, and that forms a third surface that is substantially parallel planar to the die backside second surface.

2. The processing system according to claim **1**, wherein the profile is capable of forming a meniscus where the molding cap compound originates, wherein the meniscus is formed as one selected from a capillary action meniscus and an imposed meniscus.

3. The processing system according to claim **1**, wherein the profile is capable of imposing an exposed upper surface upon a mounting substrate at a position between a first die cavity in the mold chase and a second die cavity in the mold chase.

4. The processing system according to claim **1**, wherein the profile includes a first die cavity, a second die cavity contiguous the first die cavity, and a last die cavity contiguous the first die cavity,

wherein the first die cavity, the second die cavity, and the last die cavity are arranged in a configuration selected from:

the first die cavity, the second die cavity, and the last die cavity are disposed in a single molding compound cap cavity;

the first die cavity, the second die cavity, and the last die cavity are each disposed in separate molding compound cap cavities;

the first die cavity and the second die cavity are disposed in a single molding compound cap cavity, and at least two occurrences of the last die cavity are disposed in a single molding compound cap cavity; and

the first die cavity and the second die cavity are each disposed in separate molding compound cap cavities, and at least two occurrences of the last die are disposed in a single molding compound cap cavity.

5. A process comprising:

forming a molding compound cap over a first die that is disposed upon a substrate, wherein the first die includes a first die active first surface and a first die backside second surface, and wherein forming the molding compound cap includes forming a molding compound cap third surface that is parallel planar and above the first die active first surface and below the first die backside second surface, and wherein the molding compound cap third surface includes:

a meniscus that originates substantially above the first die active first surface, wherein the meniscus is an imposed meniscus or a capillary action meniscus; and

a substantially planar surface that is parallel planar to the first die active first surface, and parallel planar located above the first die active first surface at a height that is a fraction of the die height.

6. The process according to claim **5**, further including:

forming the molding compound cap over a second die that is disposed upon the mounting substrate, wherein the second die includes a second die active first surface and a second die backside second surface, and wherein forming the molding compound cap includes forming the molding compound cap third surface parallel planar and above the second die active first surface and below the second die backside second surface.

7. The process according to claim **5**, further including:

forming the molding compound cap over a last die that is disposed upon the mounting substrate, wherein the last die includes a last die active first surface and a last die backside second surface, and wherein forming the molding compound cap includes forming the molding compound cap third surface above the last die active first surface and below the last die backside second surface.

8. The process according to claim **5**, wherein forming the molding compound cap includes injection molding the molding compound with a particulate.

9. The process according to claim **5**, further including:

forming the molding compound cap over a second die that is disposed upon the mounting substrate, wherein the second die includes a second die active first surface and a second die backside second surface, and wherein forming the molding compound cap includes forming the molding compound cap third surface above the

second die active first surface and below the second die backside second surface; and

forming the molding compound cap over a last die that is disposed upon the mounting substrate, wherein the last die includes a last die active first surface and a last die backside second surface, and wherein forming the molding compound cap includes forming the molding compound cap third surface above the last die active first surface and below the last die backside second surface.

10. The process according to claim **5**, wherein forming the molding compound cap is selected from injection molding, in situ thermal curing, pick-and-place coupling the molding compound cap with the first die, and combinations thereof.

* * * * *